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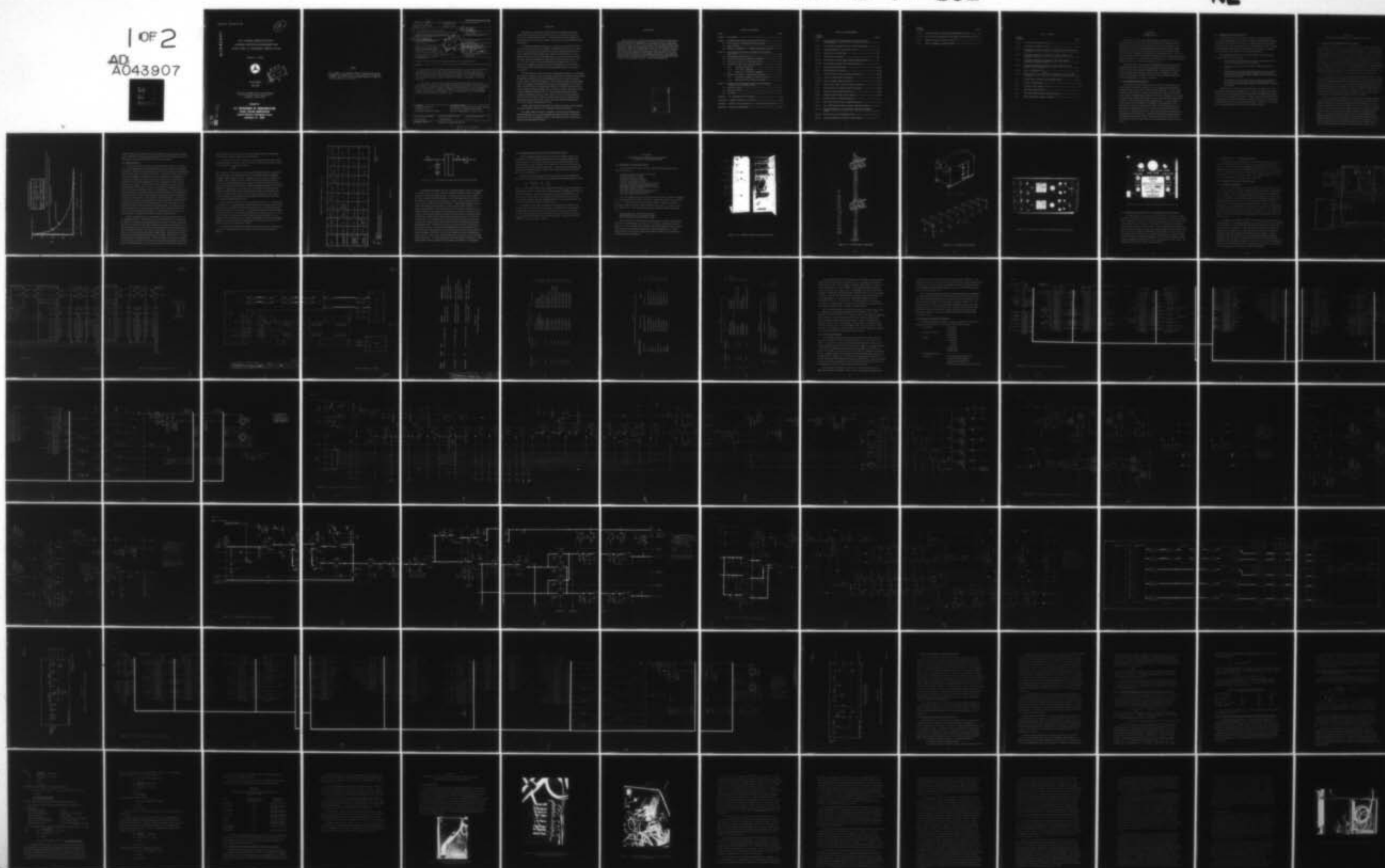

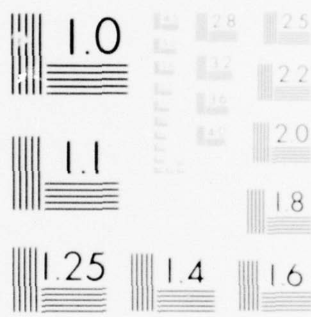
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Report No. FAA-RD-77-102

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FAA LIGHTNING PROTECTION STUDY: LIGHTNING PROTECTION REQUIREMENTS FOR WILCOX MARK I/D INSTRUMENT LANDING SYSTEM

Marvin D. Drake

Final Report

May 1977

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16. Abstract

The purpose of the Lightning Protection Study is to determine the degree of susceptibility of the Federal Aviation Administration Electronic systems to induced electromagnetic pulse effects due to lightning, and to propose protective devices adequate for low voltage electronic systems. This report covers the investigation of the protection required for one specific equipment, the Wilcox Mark I/D

The report consists of four chapters describing the lightning protection requirements, the types of susceptible components and methods used to determine their withstand capabilities and, finally, recommendations for specific protection devices and circuitry. Appendices include a cross reference to the equipment manuals, characteristics of leadless transient suppressors and a bibliography of other sources used for reference.

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FOREWORD

This effort was conducted by Florida Institute of Technology under the sponsorship of the Rome Air Development Center Post-Doctoral Program for the Federal Aviation Administration. Fred Sakate of the Federal Aviation Administration was the task project engineer and provided overall technical direction and guidance.

The RADC Post-Doctoral Program is a cooperative venture between RADC and some sixty-five universities eligible to participate in the program. Syracuse University (Department of Electrical and Computer Engineering), Purdue University (School of Electrical Engineering), and State University of New York at Buffalo (Department of Electrical Engineering) act as prime contractor schools with other schools participating via sub-contracts with the prime schools. The U.S. Air Force Academy (Department of Electrical Engineering), Air Force Institute of Technology (Department of Electrical Engineering), and the Naval Post Graduate School (Department of Electrical Engineering) also participate in the program.

The Post-Doctoral Program provides an opportunity for faculty at participating universities to spend up to one year full time on exploratory development and problem-solving efforts with the post-doctorals splitting their time between the customer location and their educational institutions. The program is totally customer-funded with current projects being undertaken for Rome Air Development Center (RADC), Space and Missile Systems Organization (SAMSO), Aeronautical Systems Division (ASD), Electronic Systems Division (ESD), Air Force Avionics Laboratory (AFAL), Foreign Technology Division (FTD), Air Force Weapons Laboratory (AFWL), Armament Development and Test Center (ADTC), Air Force Communications Service (AFCS), Aerospace Defense Command (ADC), Hq USAF, Defense Communications Agency (DCA), Navy, Army, Aerospace Medical Division (AMD), and Federal Aviation Administration (FAA).

Further information about the RADC Post-Doctoral Program can be obtained from Jacob Scherer, RADC Tel. AV 587-2543, COM (315) 330-2543.

The author wishes to thank Mr. Richard M. Cosel who participated in the field investigation, took many of the photographs and who organized, edited and prepared the report for printing; also Mrs. Lynn Harris and Mrs. Jani Mc Cray who typed and assembled the report.

BIOGRAPHY

Marvin D. Drake is an Assistant Professor of Electrical Engineering at the Florida Institute of Technology. He received the B.S.E.E. Cum Laude from the University of Toledo in 1960 and the Ph.D. from the Johns Hopkins University in 1970. He was a member of the research staff of Carlyle Barton Laboratory, Institute for Sponsored Research, The Johns Hopkins University, from 1962 to 1970. From 1970 to 1971 Dr. Drake was a member of the technical staff of TRW Systems, Washington Operations, and from 1971 to 1974 was an Associate Principal Research Engineer with the Electronic Systems Division, Harris Corporation. His publications have been on the application of electro-optic materials and devices to optical data processing and storage systems. He is a member of IEEE, Tau Beta Pi and Sigma Xi.

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CHAPTER 1
INTRODUCTION

This report is a study of the lightning damage susceptibility of and protection requirements for the Wilcox Mark I/D Instrument Landing System (ILS). This report is part of a larger study program to provide protection for communication and control electronics equipment against transient electromagnetic disturbances. Such electromagnetic disturbances cause current pulses to be induced in cables running between buildings or equipment enclosures. These currents and voltages are then coupled into terminal equipment or equipment enclosures mounted in the field. The electromagnetic disturbances may be the result of nearby lightning activity or man-made electromagnetic pulses.

The larger study, known as the FAA Lightning Protection Study, is being performed by the Post Doctoral Program through several of its member universities for the Federal Aviation Administration. The institutions include the Air Force Institute of Technology, Florida Institute of Technology, Georgia Institute of Technology, and Purdue University. The individual participants in the FAA Lightning Study are listed in Appendix A.

1.1 FAA Lightning Protection Study

Increasing use of solid state electronics in the FAA communications and control equipment means that reliance on the overvoltage protection adequate for higher voltage electron tube circuitry would be inadequate. The overvoltage protection of carbon blocks, in the several hundred volt range, and neon bulbs, with long relatively high inductance leads in the 40-100 volt range, is not adequate for the solid state circuits which operate at lower voltage levels (presently down to 5 volts). The overall study has three technical tasks: (1) determination of voltage and current levels likely to be conducted to FAA equipment; (2) the determination of the susceptibility levels of FAA solid state equipment, and (3) determination of lightning protective devices that are available to reduce the levels of (1) to those permitted by (2). These three tasks have been performed in parallel with close interaction. Appendix A lists the schools having primary responsibility of each of these tasks. The study of the Wilcox Mark I/D ILS covered in this report is a part of task (2) and draws upon the results of tasks (1) and (3).

1.2 Lightning Protection Requirements

Components in electronic circuits connected to buried control cables at FAA airport installations are susceptible to damage by lightning-induced voltage surges on the cable conductors. Devices are available which can be installed at the terminals to limit the voltage surges to levels which will cause no damage to the components in the exposed circuits; however, the selection of specific devices depends on the particular system under consideration.

The specification of the protection requirements for a given electronic system includes the following steps:

1. Characterization of lightning-induced surges on the buried control cables interconnecting various sub-systems.

2. Identification of the circuits in the system which are exposed to surges.

3. Determination of the surge withstand capabilities of the components in the actual circuit configurations using the waveshapes and the maximum peak amplitudes of surges which may be expected to occur at the circuit terminals.

4. Selection of the surge protection devices which are compatible with the withstand capabilities and normal operating characteristics of the circuits while being rugged enough to operate reliably in the surge environment.

What follows is a description of the application of the above steps to the Wilcox Mark I/D Instrument Landing System. Chapter 2 discusses the waveform and the maximum peak amplitude of voltage induced by the lightning and the protective devices available for installation. Chapter 3 discusses the methods used to determine the vulnerable components in the Mark I/D ILS, and to calculate the withstand level of each of the vulnerable components. In Chapter 4 will be given the recommended protective devices and the installation points.

CHAPTER 2

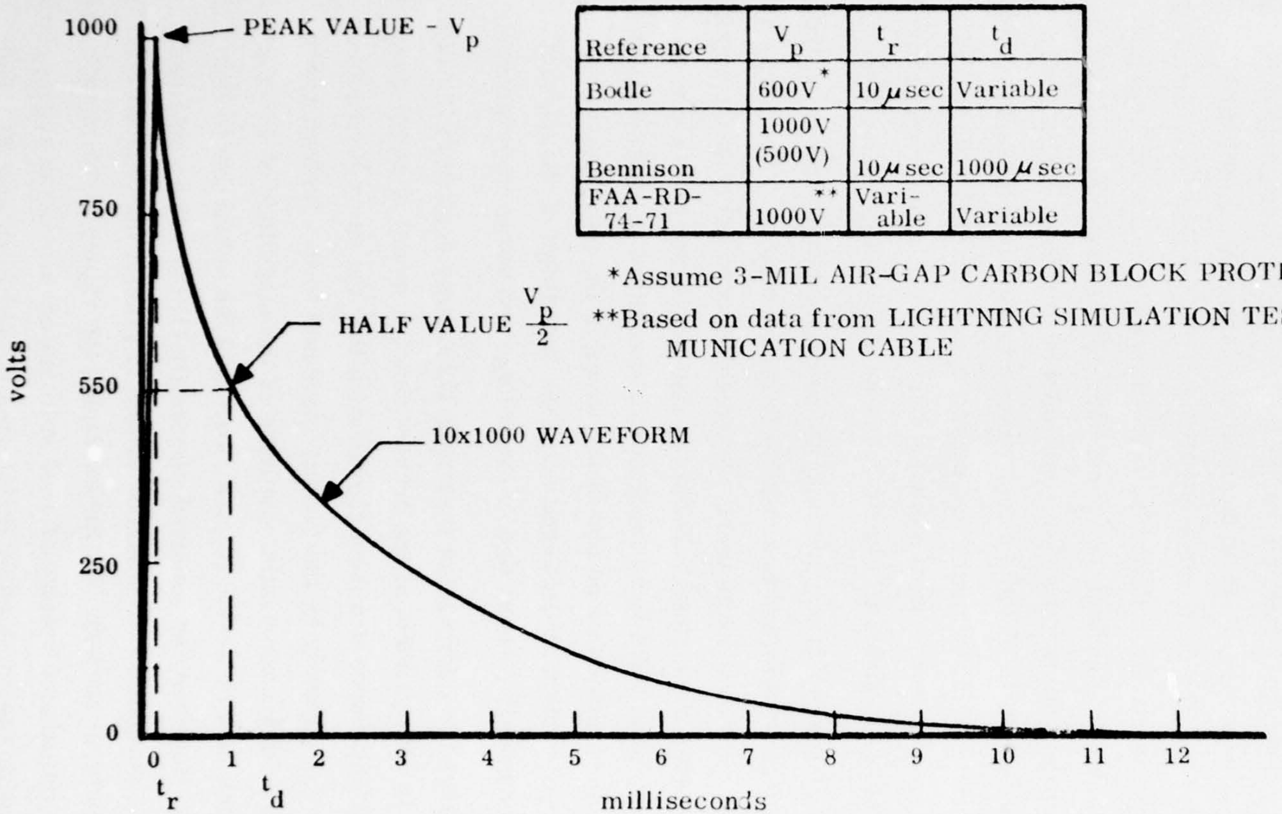
LIGHTNING INDUCED SURGES AND PROTECTIVE DEVICES

2.1 Characteristics of Lightning-Induced Transients

A number of studies, [1, 2, 3, 4, 5,] indicate that the voltage waveform due to lightning-induced surges on buried cables can be adequately described by three paramaters: rise time t_r to peak amplitude, the peak amplitude V_p, and the decay time t_d to **one-half** the peak value (all times are measured from the origin). Such a test waveform is shown in Figure 2.2-1 with a table of a waveform parameters cited in the literature. The test waveform parameters are based on long term studies of actual surges on aerial and buried telephone cables. Statistically, the parameters cited by Bennison [5] yield a test waveform which includes 99.8% of lightning-induced voltage surges in open wire and cable: t_r=10 usec, V_p=1000 volts, t_d=1000 usec. Actually, Bennison's study included buried cable with measured peak voltage of 440 volts; this is included in Figure 2.1-1 as the 500 volt entry in parentheses.

It is important to point out that no information concerning the energy content of the surge waveforms is available from the studies. The surge voltages measured were the so-called longitudinal voltages produced between the grounded cable sheath and the inner conductors. Bodle [3] also measured metallic voltages between cable pairs and found them to be insignificant compared to longitudinal voltages unless a carbon block protector on one of the wires in the pair "stuck." A determination of the energy content of the surge requires knowledge of the current and the voltage or, alternatively, knowledge of the voltage and surge impedance.

Since the information regarding the energy content of the lightning-induced surges is not available at the present time, a model of surge generators with zero internal impedance has been chosen such that the current delivered by it is determined completely by the circuit connected to it. Such an assumption naturally leads to a very conservative estimate of the magnitude of current and energy content which may be several times more than the actual due to lightning-induced surges. However, as reported previously [1] the values obtained during the lightning simulation tests can be scaled to predict the induced effects due to the larger natural strikes. If, for example, the values given in reference [1] are so scaled, an induced voltage of 1000 volts appears to be an appropriate level. It agrees with assumptions by Huddleston [6] and Bennison [5]. Unless a more



TEST WAVEFORM PARAMETERS

Reference	V_p	t_r	t_d
Bodle	600V*	10 μsec	Variable
Bennison	1000V (500V)	10 μsec	1000 μsec
FAA-RD-74-71	1000V**	Vari-able	Variable

*Assume 3-MIL AIR-GAP CARBON BLOCK PROTECTOR INSTALLED

**Based on data from LIGHTNING SIMULATION TESTS OF COMMUNICATION CABLE

Figure 2.1-1 Test Waveform for Lightning-induced Voltages on Buried Control Cables

complete model of surge generators based on information regarding energy content can be established, the present approach seems to be the most logical way to derive the necessary levels of protection for the electronic components.

2.2 Surge Protectors

As reported by Chen [7], there are two kinds of surge protectors. The first is a circuit opening device and is inserted into the circuit in series with the load to be protected. When the current level exceeds a certain preset limit, it switches from short-circuited state to its open-circuited state. Actual devices in this class, such as fuses and magnetic circuit breakers, are used extensively in residential and commercial installations. However, they are not suitable for protection of communication systems against lightning due to slow response time (of the order of milliseconds or longer). The second is a circuit shorting device and is in parallel with the load. The protective action is accomplished by changing the device from its virtually open-circuited state to a conducting state at a predetermined voltage level and thereby limiting the voltage surge and diverting the current and power away from the load. Devices in this group are gas discharge devices, dielectric-stimulated arcing connectors, semi-conductor diodes and varistors. Of these four, the dielectric-stimulated arcing connectors are not commercially available and are useful only for the protection of voltages above 1KV. Thus, they cannot be considered for application here and will not be discussed here. The other three types of protective devices are commercially available and are suitable for the protection of control and communication systems. In the following, each of their operating principles, capabilities and limitations will be discussed briefly.

The gas discharge devices are probably the best known and most widely used for lightning protection. Usually, they are operated in either the arc discharge or the abnormal region of the gas discharge where the voltage is virtually constant and the current is limited and controlled completely by external circuit parameters. At the present time, there are two basic types of gas discharge devices which may be used as transient protectors: glow lamps and spark gaps. Glow lamps are characterized by low current capability and relatively high voltage. While inexpensive, they cannot provide adequate and long lasting protection against transients for low voltage systems such as communication lines. On the other hand, spark gaps are designed to operate in the arc mode and are capable of absorbing large amounts of current and power. One disadvantage, as far as the present study is concerned, is that they are

only available with a clamping level of 75 volts and higher which is substantially larger than the protective requirements of the system.

A metal-oxide (zinc-oxide) varistor is a two terminal device having a voltage-dependent nonlinear resistance. The volt-ampere characteristic of an ideal varistor can be expressed as an empirical relation,

$$I = \frac{V^{\alpha}}{C}$$

where V and I are the voltage across and current through the caristor, respectively, The exponent α is an important parameter and represents the power handling capability of this particular varistor. Among the various varistors commercially available, silicon carbide (Thyrite), selenium cells (thyristor diodes), $BaTiO_3$ varistors and zinc oxide-bismuth oxide varistors are the well known ones. However, only the ZnO-Bi_2O_3 has the large power handling capabilities suitable for the present application. Furthermore, its response time is much faster than the spark gap. It thus has virtually all the desired characteristics except one for transient protection. The undesirable feature is that it can clamp voltage only in the range of 57 volts and higher and is doubtful that this magnitude can be lowered any further due to present manufacturing processes.

Both of the above protective devices are bipolar in nature, i.e., a given device can clamp at $\pm V$. Avalanche diodes, on the other hand, are unipolar devices clamping at zero volts when biased in the forward direction and at its breakdown voltage when biased in the reverse direction. The breakdown mechanism is attributed either to the Zener effect, or to the avalanche multiplication of charge carriers, or a combination of both. Furthermore, avalanche diodes can clamp voltages as low as five volts with the fastest response. Its main disadvantage is its low power-handling capability. It can be improved by methods such as a resistance in series with the diode or several diodes connected in parallel.

A comparison of available protection devices is given here for convenience in Table 2.2-1. The table is based on a detailed report on protective devices by Chen [7].

Comparison of Transient Protectors (7) (8) (9) (10)

Type	Polarity	Failure Mode	Condition when activated	Self extinguish after surge	Response time (d) (second)	Capacitance (Farads)	Peak Idle Current or Stand-by Drain (Amperes)	Max Current for 1 ms. Pulse (Amperes)	Peak Energy (1ms pulse) (Joules)	Voltage Range for Commercially Available Units (Volts)
Gas Discharge Devices (a)	Bipolar	Open	Almost short-circuited	Yes (ac). Only if Properly Designed (dc).	$\sim 10^{-6}$	$10^{-11} \sim 10^{-12}$	$10^{-9} \sim 10^{-12}$	10^3 or larger	$10^2 \sim 10^3$	75(± 20%) ~ 10^4
Semiconductor Breakdown Diodes (b)	Unipolar	Short	Clamped	Yes	$\sim 10^{-9}$	$10^{-7} \sim 10^{-10}$	$10^{-5} \sim 10^{-6}$	1~10	$10^{-2} \sim 10^{1}$	4~200
$ZnO-Bi_2O_3$ Varistors (c)	Bipolar	Degraded then short	Clamped	Yes	$\sim 10^{-9}$	$10^{-8} \sim 10^{-10}$	$\sim 10^{-3}$	50~100	$1 \sim 10^2$	33~4400

Notes:

a) Spark gaps
b) 50-watt units designed for voltage reference or transient protection applications
c) GE MOV varistors with 26.21 mm O.D.
d) Estimated values, valid for leadless devices

Courtesy C.L. Chen
(Ref. 7)

Table 2.2-1

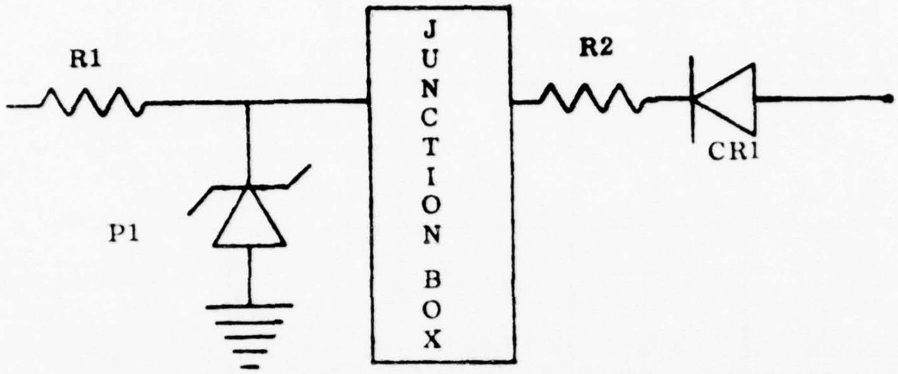


Figure 2.2-1. A Generalized Protection System for ILS Control Lines

A generalized protection system for ILS control circuitry cables is shown above. The circuit consists of a surge protector connected in parallel from the susceptible terminals in the junction box to ground. It is pointed out in the previous reports 4,7 that surge protectors should be installed as close to the junction box as possible so that both the traveling wave and reflecting wave due to surges are limited to safe values at the terminals of the protected circuit. A good ground should also be provided in the junction box for connection of the ground side of the protector. In general, the protective system P1 consists of any of the three surge protectors previously mentioned. If the choice of surge protectors is either a spark gap or MOV varistor, the breakdown voltages chosen must be greater than the operating voltage but below the withstand levels of both negative and positive surges of the element in the circuit. For avalanche diodes, only the positive surge level has to be considered since a negative surge forward-biases the diode and clamps the voltage to approximately zero. Resistors R1 and R2 may be placed in series with the line to limit surge current to a safe value for the protector and to limit circuit current that may flow from the protected side of the line in the event that the surge protector fails by shorting. Diode CR1 is added on the protected side to give additional protection in case of failure in the surge protector device for certain types of communication sub-systems. As shown in Chapters 3 and 4 and Tables 4-1 through 4-5, only those protective devices required by the specific circuit involved are designated.

2.3 Withstand Capabilities of Avalanche Diode Surge Protectors

Since the clamping requirement for most of the susceptible circuits of the Wilcox Mark I/D ILS is unipolar and below 30 volts, the avalanche diodes will be used extensively. Because of the relatively low power-handling capabilities of avalanche diodes, series resistance (R1 in Figure 2.2-1) may be used to limit the surge current in the diode itself to safe levels. A procedure for selecting the value of this series resistance R1 for avalanche diode is presented which is essentially the same as in Reference [6].

The value of series resistance R1 is determined by the surge-handling data provided for the avalanche diode and can be calculated from the following expression,

$$R1 = \frac{V_o - V_{BD}}{I_{pp}} \approx \frac{V_o}{I_{pp}}$$

where V_o is the peak amplitude of the expected voltage surge, V_{BD} is the breakdown voltage of the diode and is usually very small compared to V_o, and I_{pp} is the safe peak current for the diode. *This safe peak current* I_{pp} *can* be obtained from the data sheet for the avalanche diodes (see Appendix B). It should be noted that the safe peak current I_{pp} applies when the avalanche diode is reverse biased; the diode will handle a larger peak current when forward biased.

The bipolar version of the avalanche diode mentioned above consists of two avalanche diodes connected in series opposed. The method of determining the resistance value R1 to limit the current to the safe peak current I_{pp} is the same as for the unipolar diode but it must be done for each polarity (unless the voltage V_{BD} is ignored) and the higher value of resistance used. This will be described further in examples in Chapters 3 and 4.

CHAPTER 3

DETERMINATION OF WITHSTAND CAPABILITIES AND PROTECTION REQUIREMENTS

3.1 Description of Wilcox Mark I/D ILS

The equipment considered in this study include the following units of the Wilcox Mark I/D ILS:

Localizer/Glide Slope Control Unit (FA-9355)
Glide Slope Monitor (FA-9370)
Localizer Monitor (FA-9357)
Glide Slope Transmitter (FA9369)
Localizer Transmitter (FA-9353)
Localizer/Glide Slope RF Power Panel (FA-9356)
Localizer/Glide Slope Power Supply (FA-9354)
Glide Slope Monitor Combining Network (FA-9372)
Glide Slope Antenna (FA-9373)
Glide Slope Monitor Detector/Antenna (FA-9371)
Glide Slope Tower Tilt Monitor (FA-9378)
Localizer Antenna Array (FA-9358)

The corresponding instruction manuals for the above units are listed in Appendix B. A typical installation of either a Localizer or Glide Slope Station is shown in Figures 3.1-1. (This equipment is located inside a shelter). Figure 3.1-2 shows a Glide Slope Antenna and Monitor Detector/Antenna and Figure 3.1-3 shows a Localizer Antenna Array. Other equipment in the ILS system not included in this study were:

Localizer Receivers (FA-9387 and FA-9414)
Glide Slope Receivers (FA-9389 and FA-9415)
Remote Status Units (FA-9391 and FA-9416)

These units inform control tower personnel when the Localizer and Glide Slope Stations are not functioning. (See Figure 3.1-4) However, since they are remote units, i.e. are not connected to the Localizer/Glide Slope Equipment through control lines, they were not considered vulnerable to induced lightning pulses. Marker Beacon Stations were also not included in this study since they are not connected to the Wilcox Mark I/D equipment.

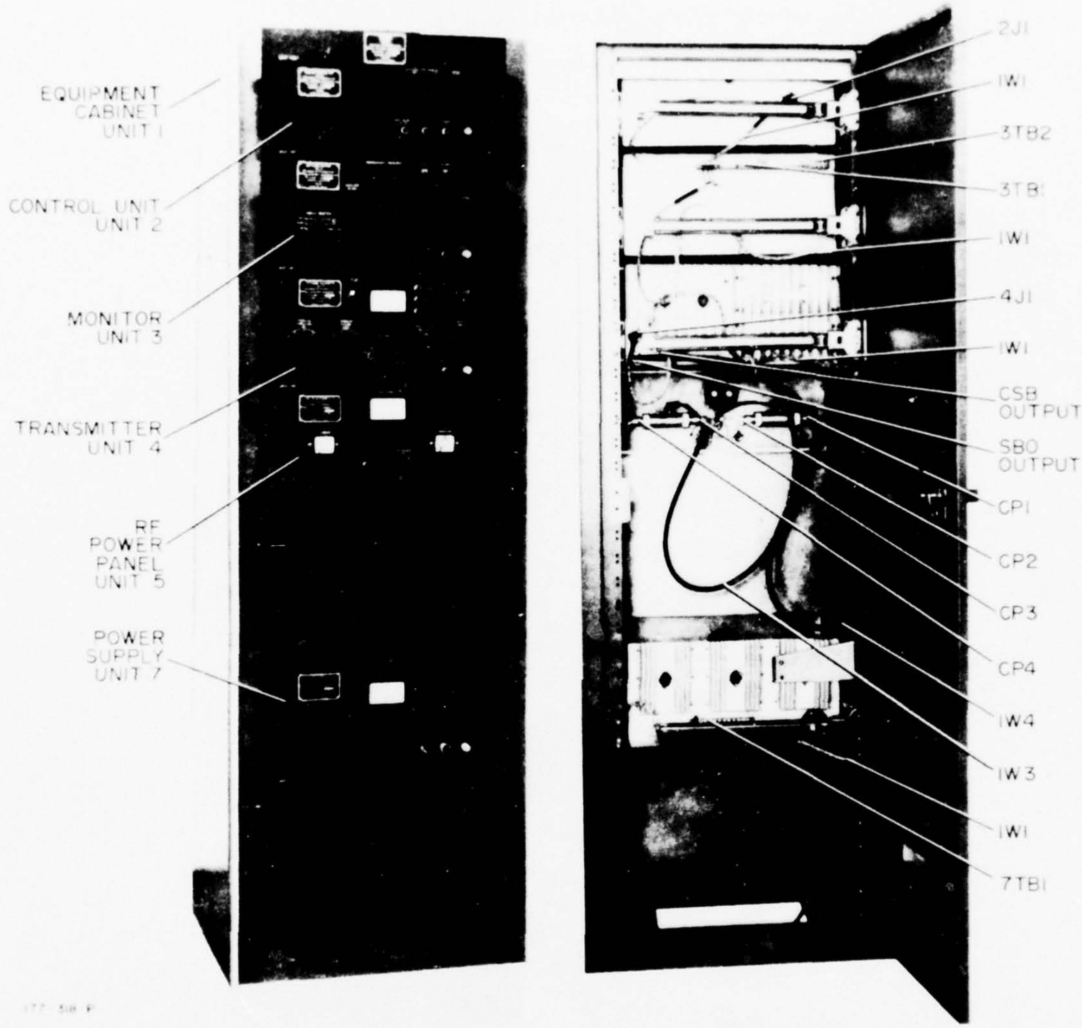


Figure 3.1-1. Equipment Cabinet, Front and Rear Views

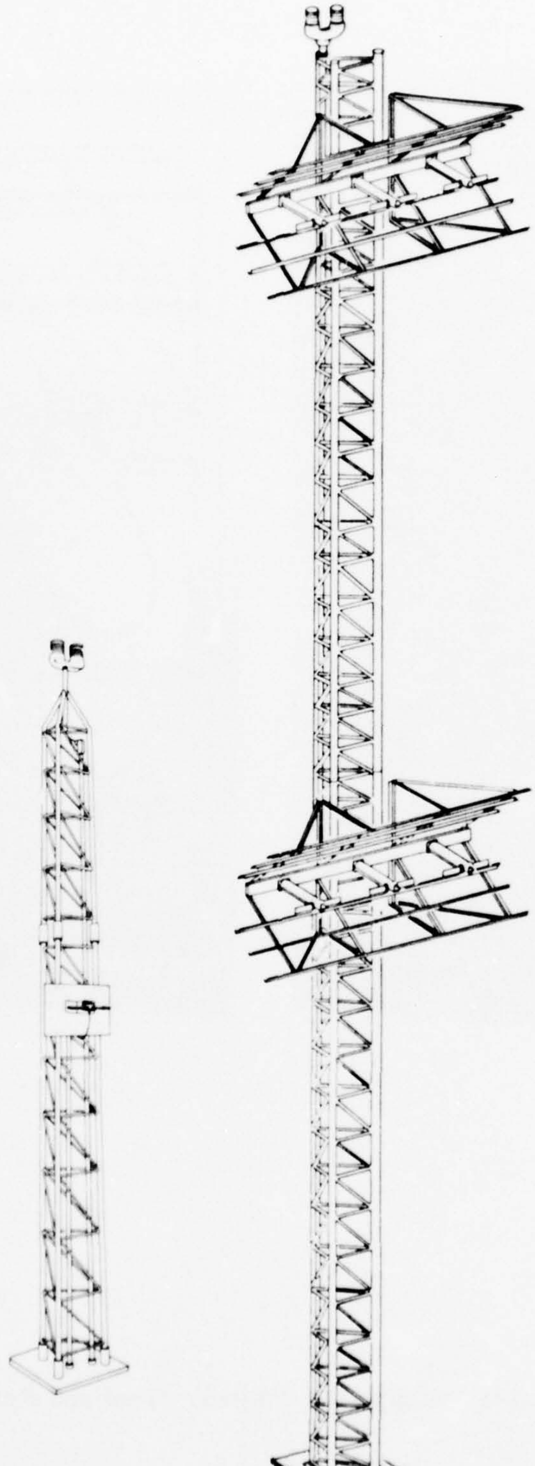


Figure 3.1-2. Antenna System, Glide Slope

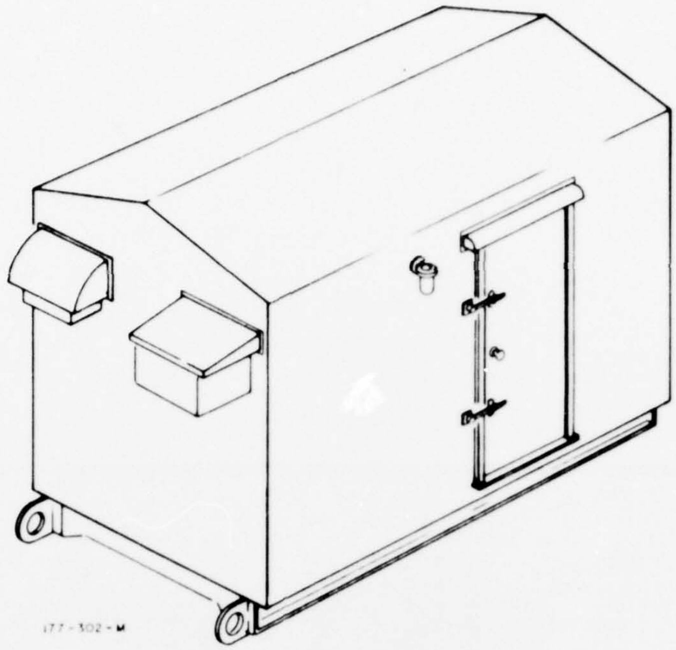


Figure 1-3. Shelter

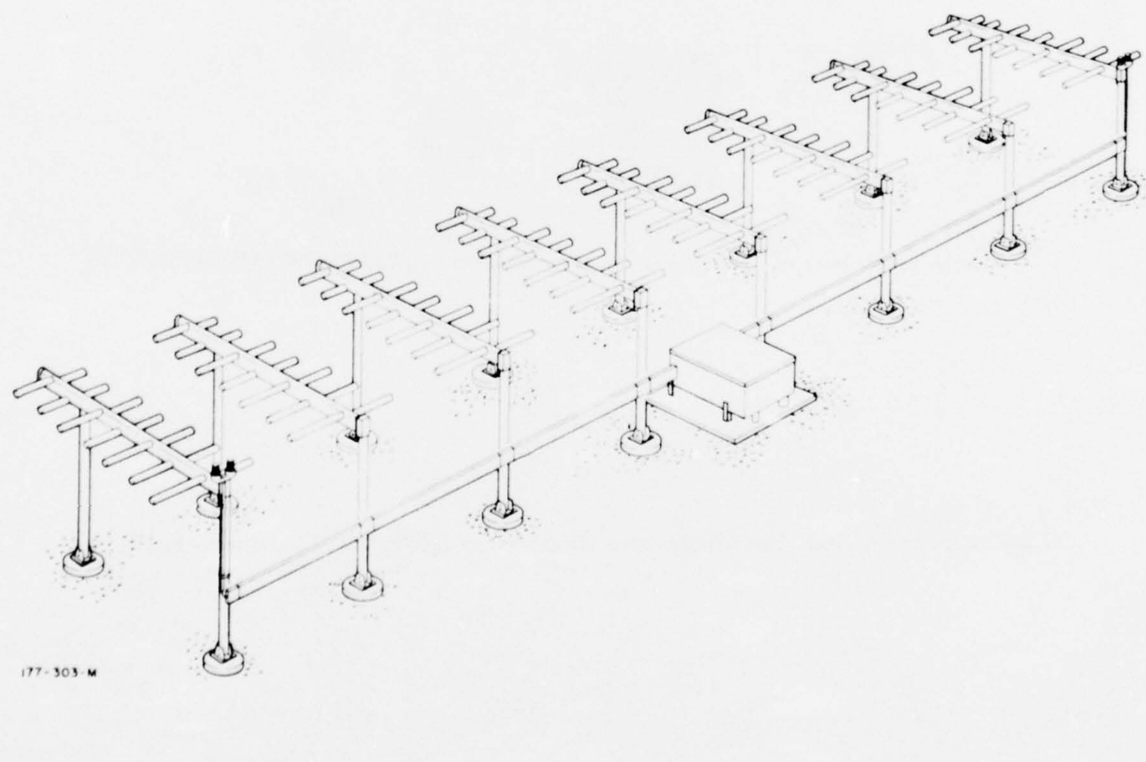


Figure 3.1-3. Antenna Array, Localizer

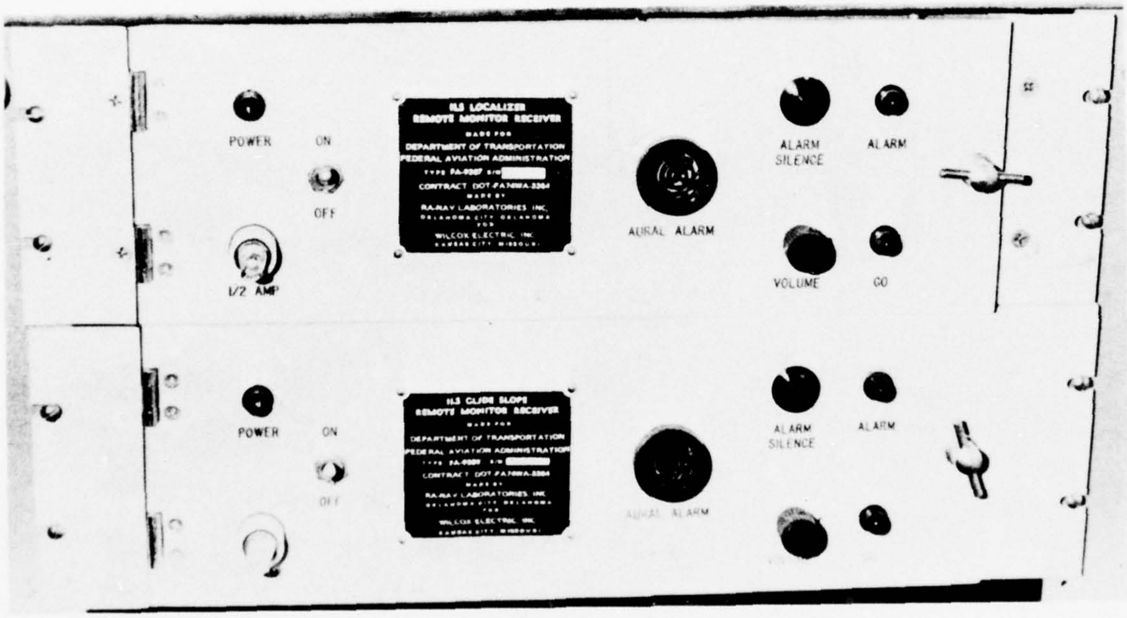


Figure 3.1-4A ILS Localizer and Glide Slope Remote Monitor Receivers

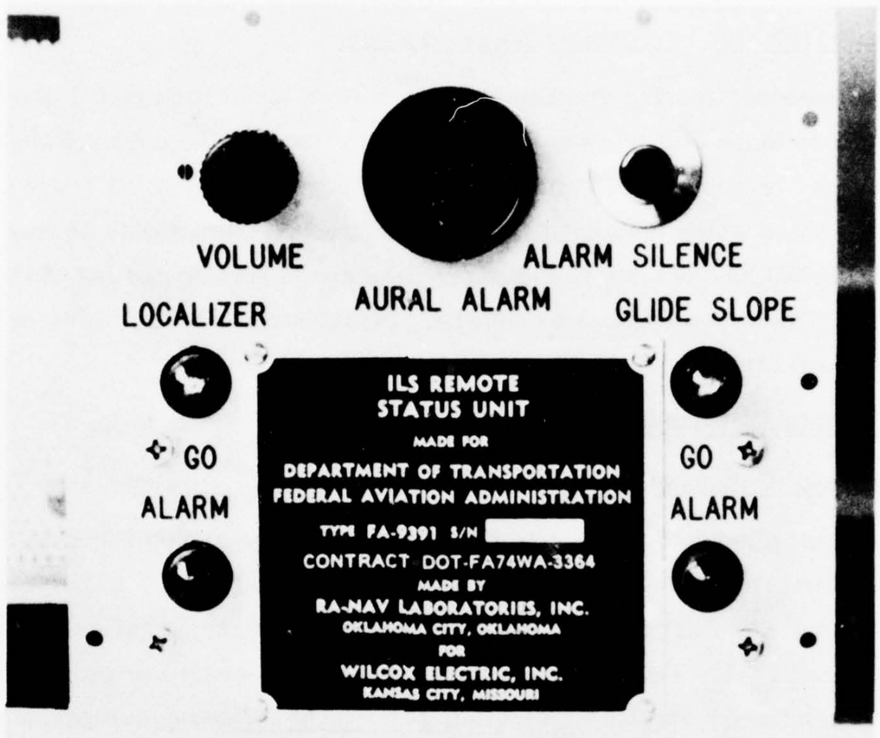


Figure 3.1-4B ILS Localizer and Glide Slope Remote Status Unit

3.2 Method of Determining Vulnerable Components of the Wilcox I/D ILS

The vulnerability of components of the Wilcox I/D ILS to damage by voltages induced on transmission and control lines was investigated by the following method. The starting point was to assume a maximum induced surge level and probable pulse shape based on studies done under Part 1 of the FAA Lightning Protection Study and described in Section 2.1 of this report. Next, the circuit and installation diagrams from the manufacturers were examined to find which transmission and control lines were located outside of the lightning protected shelters. Following this, the components of the I/D ILS that were connected directly to these unprotected lines were determined. The withstand capabilities of each of the vulnerable components was then calculated, and where necessary, protective devices recommended. The listing of protective devices will be given in Chapter 4.

3.3 Cables which may be Possible Surge Sources

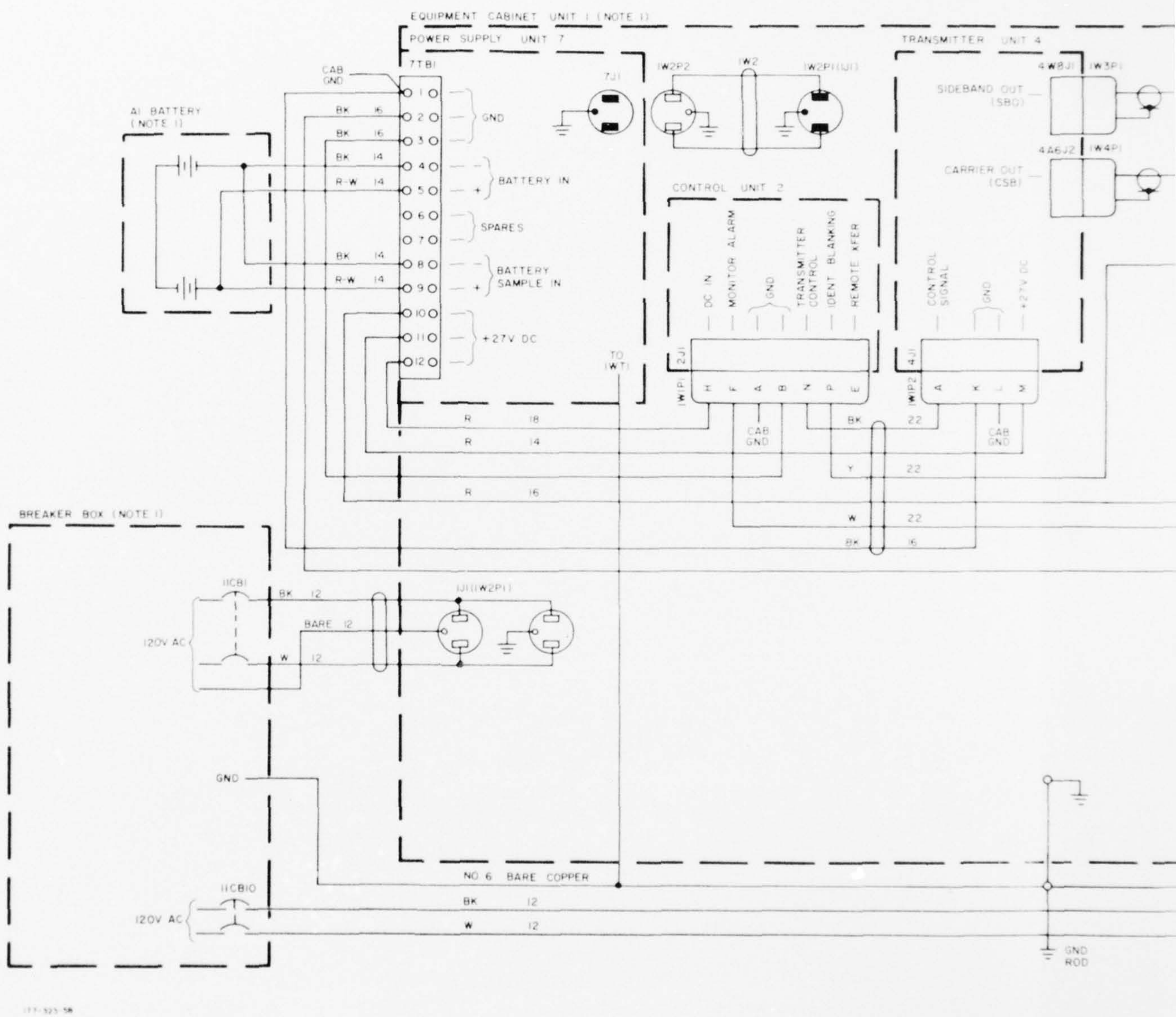
The interconnect wiring diagrams for the Localizer Station (see Figure 3.3-1) and for the Glide Slope Station (see Figure 3.3-2) show that the cables listed in Table 3.3-1 may be sources of lightning induced surges. Cables W4 and W8 are both buried cables which may have impulses induced on them due to nearby ground strikes. Cable W9 has an open run of approximately 30 feet up one leg of the Glide Slope Antenna Tower unprotected by conduit. Direct strikes to the tower as well as nearby ground strikes may induce pulses in this cable.

3.4 Components Vulnerable to Lightning Surges

3.4.1 Localizer Components

The circuit diagrams of the circuits connected to the cables listed in Table 3.3-1 were examined to see which components could be vulnerable to pulses induced on these cables. The first circuits examined were that of the Localizer Monitor shown in Figure 2.4-1. The potentially vulnerable components are listed in Table 3.4-1. Through the connection to terminal 3TB1-9 the following components were considered vulnerable: CR1 (1N4384), Q1 and Q2 (JAN 2N3055), VR1 and VR2 (JAN 1N749A), and DS-1 through DS-10 (indicator lamps). Through connections to the indicator lamps, the following components may be vulnerable: 3A6-Q6 through Q-10 (JAN 2N1711) on the Alarm Assembly Card (see Figure 3.4-2), 3A8-Q2 (JAN 2N1711) on the Antenna Cable Fault Assembly (see Figure 3.4-3) and 3A3-Q1 (JAN 2N1711) and 3A3-CR4 (JAN 1N4148) on the Signal Processor Assembly Card (see Figure 3.4-4).

The connection of Cable W4 to 1TB1-3 then to 3TB1-11 (Zero Ref. Pulse Out) makes the following components vulnerable: 3A4-Q1 (2N1711) on the Timing Assembly Card (see Figure 3.4-5), 3Q1 and 3Q2 (JAN 2N3055) on the Monitor Main Frame +8 Volt supply, (see Figure 3.4-1) and 3A6-VR1 (JAN 1N748A) on the Alarm Assembly Card (see Figure 3.4-2). The connections to 1TB1-5 (Course Detected Signal In) and to 1TB1-7 (Width Detected Signal In) from Cable W4 continue to terminals 3TB2-1 and 3TB2-3 respectively, making the following components vulnerable: 3A1-U1A (MC 1558) and 3A1-VR1 (1N748A) on the Course Channel Signal Processor Assembly (see Figure 3.4-4) and 3A2-U1A (MC 1558) and 3A2-VR1 (1N748A) on the Width Signal Processor Assembly (see Figure 3.4-4). In addition the +8 volt supply on the main frame may also be vulnerable.



EQUIPMENT CABINET UNIT 1 (NOTE 1)
POWER SUPPLY UNIT 7
7TB1
CAB GND
GND
BATTERY IN
SPARES
BATTERY SAMPLE IN
+27V DC
A1 BATTERY (NOTE 1)
7J1
1W2P2
1W2
1W2P1(1J1)
TRANSMITTER UNIT 4
4W8J1
1W3P1
SIDEBAND OUT (SBO)
4A6J2
1W4P1
CARRIER OUT (CSB)
CONTROL UNIT 2
DC IN
MONITOR ALARM
GND
TRANSMITTER CONTROL
IDENT BLANKING
REMOTE XFER
CONTROL SIGNAL
+27V DC
2J1
1W1P1
4J1
1W1P2
TO 1WT
CAB GND
BREAKER BOX (NOTE 1)
11CB1
120V AC
1J1(1W2P1)
BARE 12
GND
11CB10
NO 6 BARE COPPER
GND ROD

Figure 3.3-

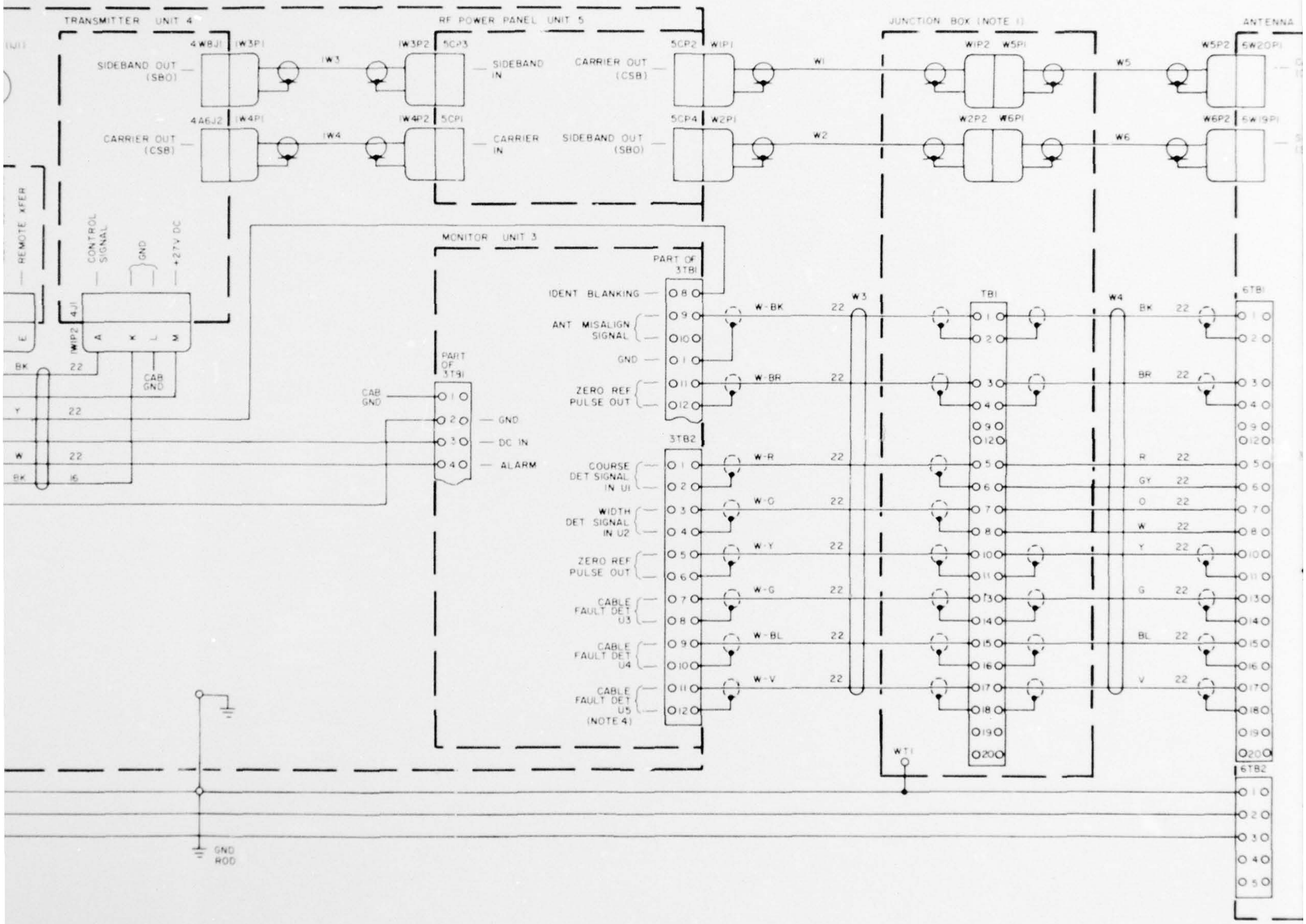
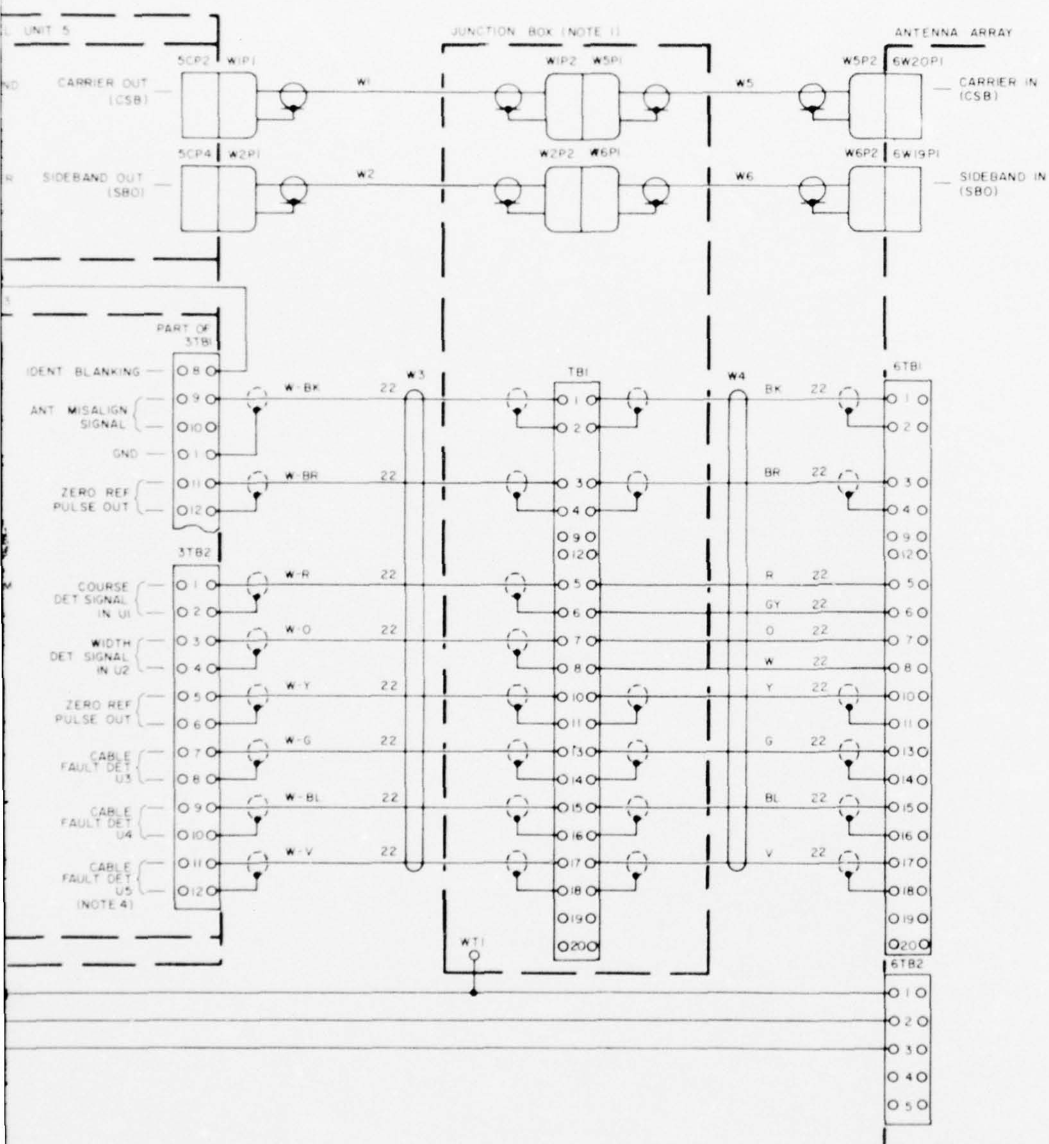


Figure 3.3-1

Interconnect Wiring Diag

From:
TI6750.90



NOTES
1. LOCATED IN SHELTER
2. WIRE IDENT

COLOR CODE	WIRE SIZE
BK	22

3. WIRE COLOR CODE

WIRE COLOR	CODE
BLACK	BK
BROWN	BR
RED	R
ORANGE	O
YELLOW	Y
GREEN	G
BLUE	BL
VIOLET	V
GRAY	GY
WHITE	W

4. U5 USED ONLY IN WIDE APERTURE ANTENNA ARRAY

Interconnect Wiring Diagram (Sheet 2 of 2)

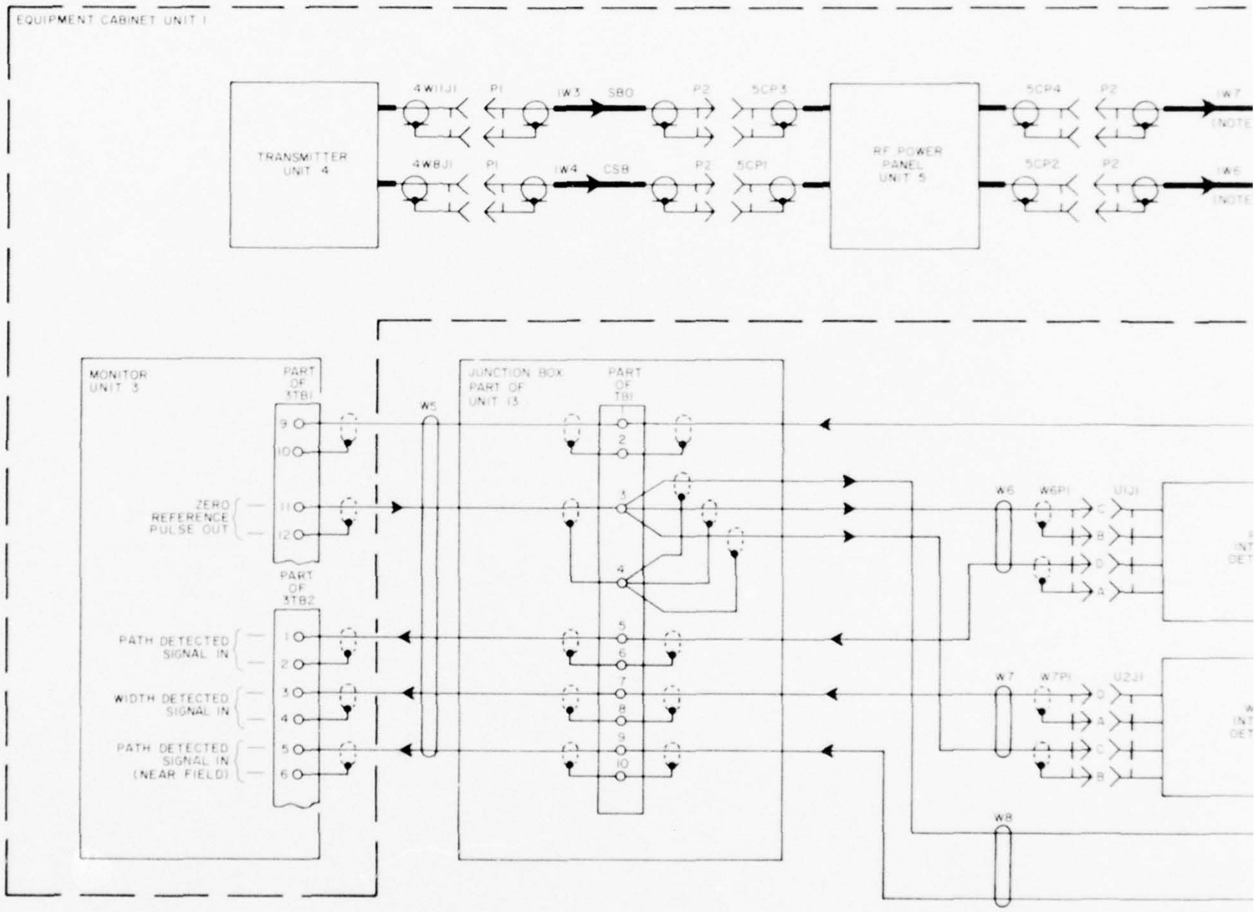
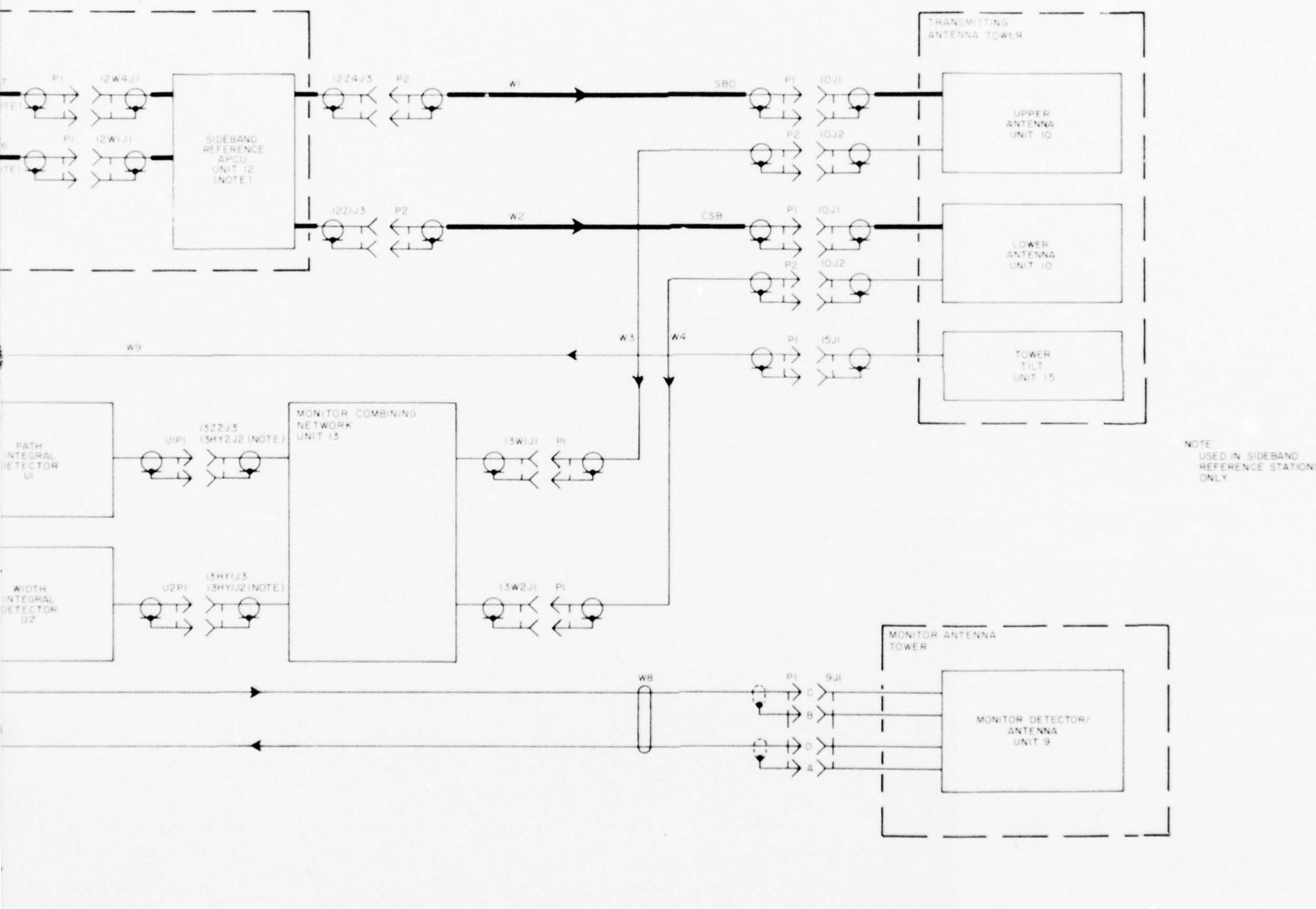

EQUIPMENT CABINET UNIT 1
TRANSMITTER UNIT 4
4W1J1
4W8J1
P1
P2
1W3
1W4
SBO
CSB
5CP3
5CP1
5CP4
5CP2
RF POWER PANEL UNIT 5
1W7
1W6
MONITOR UNIT 3
PART OF 3TB1
PART OF 3TB2
ZERO REFERENCE PULSE OUT
PATH DETECTED SIGNAL IN
WIDTH DETECTED SIGNAL IN
PATH DETECTED SIGNAL IN (NEAR FIELD)
W5
JUNCTION BOX PART OF UNIT 13
PART OF TB1
W6
W6P1
U1J1
W7
W7P1
U2J1
W8

Figure 3.

From:
TI6750.78



3.3-2

Station Signal Flow Diagram

Station	Cable	Type	Connects	Vulnerable Units
Localizer	W4	10 pr, #22 shielded audio	Antenna Array 6TB1 to Junction Box 1TB1	Localizer Monitor, Antenna Misalignment Switch, Integral Detectors
Glide Slope	W8	2 pr, #22 shielded audio	Monitor Detector/Antenna to Junction Box 13TB1	Glide Slope Monitor, Monitor Detector/Antenna Integral Detector
Glide Slope	W9	3 wire, #22 shielded audio	Antenna Tower Tilt Switch to Junction Box 13TB1	Glide Slope Monitor Antenna Tower Tilt Switch

Table 3.3-1
Cable Sources of Induced Surges

Table 3.4-1

Potentially Vulnerable Components in Localizer Monitor Connected to Cable W4

Pin Connection to Cable W4 in Junction Box 1	Pin Connection to Localizer Moniter	Components and Type	Location in Localizer Monitor	Figure
1TB1-1	3TB1-9	CR1 (1N4384)	Monitor Mainframe	3.4-1
		Q1 and Q2 (JAN 2N3055)	Monitor Mainframe	3.4-1
		VR1 and VR2 (JAN 1N749A)	Monitor Mainframe	3.4-1
		DS-1 through DS-10 (lamps)	Monitor Mainframe	3.4-1
		3A6-Q6 through -Q10 (JAN 2N1711)	Alarm Assembly Card	3.4-2A
		3A8-Q2 (JAN 2N1711)	Antenna Cable Fault Assembly	3.4-3
		3A3-Q1 (JAN 2N1711)	Signal Processor Assembly	3.4-4
		3A3-CR4 (JAN 1N4148)	Signal Processor Assembly	3.4-4
1TB1-3	3TB1-11	3A4-Q1 (1N1711)	Timing Assembly Card	3.4-5
		Q1 and Q2 (JAN 2N3055)	Monitor Mainframe +8 volt supply	3.4-1
		3A6-VR1 (JAN 1N748A)	Alarm Assembly Card	3.4-2B
		VR2 (JAN 1N749A)	Monitor Mainframe +8volt supply	3.4-1
1TB1-5	3TB2-1	3A1-U1A (MC 1558GH2)	Course Channel Signal Processor Assembly	3.4-4
		3A1-VR1 (1N748A)	Course Channel Signal Processor Assembly	3.4-4
1TB1-7	3TB2-3	3A2-U1A (MC 1558GH2)	Width Channel Signal Processor Assembly	3.4-4
		3A2-VR1 (1N748A)	Width Channel Signal Processor Assembly	3.4-4
1TB1-10	3TB2-5	3A8-U3B (MC 1558GH2)	Antenna Cable Fault Assembly	3.4-3
		3A8-U2 (CD 4016AD3)	Antenna Cable Fault Assembly	3.4-3
1TB1-13	3TB2-7	3A8-U1B (MC 1558GH2)	Antenna Cable Fault Assembly	3.4-3
		3A8-VR1 (1N748A)	Antenna Cable Fault Assembly	3.4-3
1TB1-15	3TB2-9	3A8-U1A (MC 1558GH2)	Antenna Cable Fault Assembly	3.4-3
		3A8-VR1 (1N748A)	Antenna Cable Fault Assembly	3.4-3
1TB1-17	3TB2-11	3A8-U4A (MC 1558GH2)	Antenna Cable Fault Assembly	3.4-3
		3A8-VR1 (1N748A)	Antenna Cable Fault Assembly	3.4-3

Table 3.4-2

Potentially Vulnerable Components In Localizer Antenna Array Connected to Cable W4

Pin Connection to Cable W4 at terminal block 6TB1	Components and Type	Location	Figure
6TB1-1 and 2	Antenna Misalignment Switch 1HS41	Antenna Array	3.4-6
6TB1-3	CR1, CR2 (HP5082-3077)	Integral Detectors U1, U2	3.4-6,7
6TB1-4	CR1, CR2 (HP5082-3077)	Integral Detectors U1, U2	3.4-6,7
6TB1-5	CR3 (HP5082-2800)	Integral Detectors U1	3.4-6,7
6TB1-7	CR3 (HP5082-2800)	Integral Detectors U2	3.4-6,7
6TB1-10 and 11	CR1, CR2 (HP5082-3077)	Integral Detectors U3, U4, U5	3.4-6,7
6TB1-13	CR3 (HP5082-2800)	Integral Detectors U3	3.4-6,7
6TB1-15	CR3 (HP5082-2800)	Integral Detectors U4	3.4-6,7
6TB1-17 (if installed).	CR3 (HP5082-2800)	Integral Detectors U5	3.4-6,7

Table 3.4-3

Potentially Vulnerable Components in Glide Slope Monitor Connected to Cables W8 and W9

Cable	Pin Connection in Junction Box 13	Pin Connection to Glide Slope Monitor	Components and Type	Location	Figure
W9	13TB1-1	3TB1-9	CR1 (IN4384)	Monitor Mainframe	3.3-2, 3.4-8
			Q1 and Q2 (JAN 2N3055)	Monitor Mainframe	3.3-2, 3.4-8
			VR1 and VR2 (JAN 1N749A)	Monitor Mainframe	3.3-2, 3.4-8
			DS-1 through DS-10 (lamps)	Monitor Mainframe	3.3-2, 3.4-8
			3A6-Q1, Q6 through Q10, Q14 (JAN 2N1711)	Alarm Assembly	3.4-2A
			3A3-Q1 (JAN 2N1711)	Near Field Path Signal Processor Assembly	3.4-4
W9	13TB1-2	3TB1-10	3A3-Q1 (JAN 2N1711)	Near Field Path Signal Processor Assembly	3.4-4
			CR4 (JAN 1N4148)	Near Field Path Signal Processor Assembly	3.4-4
W8	13TB1-3	3TB1-11	3A4-Q1 (2N1711)	Timing Assembly	3.4-5
			3A6-VR1 (JAN 1N748A)	Alarm Assembly	3.4-2B
			3Q1 and Q2 (JAN 2N3055)	Mainframe +8 volt supply	3.4-8
			VR2 (JAN 1N749A)	Mainframe +8 volt supply	3.4-8
W8	13TB1-9	3TB2-5	3A3-U1A (MC1553GH2)	Near Field Path Signal Processor Assembly	3.4-4
			3A3-VR1 (1N748A)	Near Field Path Signal Processor Assembly	3.4-4

Table 3.4-4

Potentially Vulnerable Components in Glide Slope Tower Tilt Monitor and Monitor Detector/Antenna

Cable	Plug and Jack Pin Connections	Components and Type	Location	Figure
W9	W9P1-15J1-A and C	Antenna Tilt Switch, Wilcox Manufactured	Antenna Tower, Tilt Switch, Unit 15	3.3-2
W8	W8P1-9J1-C	CR1, CR2 (HP5082-3077)	Near Field Monitor Detector/Antenna	3.3-2, 3.4-9
W8	W8P1-9J1-B	CR1, CR2 (HP5082-3077)	Near Field Monitor Detector/Antenna	3.3-2, 3.4-9
W8	W8P1-9J1-D	CR3 (HP5082-2800)	Near Field Monitor Detector/Antenna	3.3-2, 3.4-9

The connection of cable W4 to terminal 1TB1-10 and then to terminal 3TB2-5 of the Localizer Monitor leads to the 500 Hz sine wave oscillator of the Antenna Cable Fault Assembly. The components potentially vulnerable here are the operational amplifier 3A8-U3B (MC 1558GH2) and the quadrature bilateral switch 3A8-U2 (CD4016AD3) (see Figure 3.4-3). Additionally, the Antenna Cable Fault Assembly is potentially vulnerable through connections 1TB1-13, 15 and 17 leading to 3TB2-7, 9 and 11. The connections are to identical circuits (Cable Fault Detector Signal Inputs U3, U4 and U5) whose vulnerable component is 1/2 of a MC1558GH2 (3A8-U1A, -U1B and -U14A). The signal input U5 is only used on wide aperture antenna systems. On the same card, all of these connections lead to the voltage regulator in the +4V supply, 3A8-VR1 (IN748A).

Other vulnerable components connected to cable W4 are located in the Localizer Antenna Array through terminal block 6TB1 (see Figure 3.4-6). These components are listed in Table 3.4-2. The first of these is the antenna misalignment switch, which is connected to terminals 6TB1-1 and 2 and is normally closed. The remaining potentially vulnerable components are diodes containing in the Integral Detectors U1(Course), U2(Width), U3(Cable Fault), U4(Cable Fault) and U5(Cable Fault); detector U5 is only installed in Wide Aperture Systems. These detectors are all identical as shown in Figure 3.4-7, and the vulnerable components are CR1 and CR2 (HP5082-3077) and CR3 (HP5082-2800).

3.4.2 Glide Slope Components

The potentially vulnerable components in the Glide Slope Monitor through connections to Cables W9 and W9 are listed in Table 3.4-3. (see Figures 3.3-2 and 3.4-8). This circuit connects to the Antenna Tilt Switch and is similar to the Antenna Misalignment Switch Circuit in the Localizer Monitor. Through connections to Pin 3TB1-9, the following components may be vulnerable: CR1 (1N4384), Q1 and Q2 (JAN 2N3055), VR1 and VR2 (JAN 1N 749A) and DS-1 through DS-10 (indicator lamps). Through connections to the indicator lamps, the following components may be vulnerable (see Figure 3.4-2): 3A6-Q1, and Q-6 through Q-10, and Q-14 (JAN 2N1711) on the near Field Path Signal Processor Assembly Card. On the same Signal Processor Card, the components 3A3-Q1 (JAN 2N1711) and CR4 (JAN 1N4148) may be vulnerable since they are connected to Cable W9 at 13TB1-2.

The connection of Cable W8 to 13TB1-3 (Zero Ref. Pulse Out) leaves the following components vulnerable: 3A4-Q1 (2N1711) on the Timing Assembly Card

(see Figure 3.4-5), 3Q1 and Q2 (JAN 2N3055) on the Monitor Mainframe +8 volt supply (see Figure 3.4-1) and 3A6-VR1 (JAN 1N748A) on the Alarm Assembly Card (see Figure 3.4-2). The connection of Cable W8 to 13TB1-9 and then to the Near Field Path Signal Processing Assembly leads to 3A3-U1A (MC1558GH2) and 3A3-VR1 (1N748A) (see Figure 3.4-4).

The remaining components in the Glide Slope Station that may be vulnerable are contained in the Antenna Tower Tilt Switch connected to cable W9 and in the Near-Field Monitor Detector/Antenna connected to Cable W8 (see Figure 3.3-2). These components and their cable connections are listed in Table 3.4-4. The Antenna Tower Tilt Switch is a normally open "pendulum in a donut" type, manufactured by Wilcox. The Near-Field Monitor Detector/Antenna Unit is similar to the Integral Detectors used in the Localizer Station and contains the same vulnerable components: CR1 and CR2 (HP5082-3077) and CR3 (HP5082-2800) (see Figure 3.4-9.)

3.4.3 Summary of Vulnerable Components

The following list contains all of the components judged to be vulnerable to lightning surges in the Wilcox 1/D Glide Slope and Localizer Stations:

(1) Transistors:	JAN 2N3055
	JAN 2N1711
(2) Integrated Circuits:	MC1558GH2
	CD4016AD3
(3) Diodes:	JAN 1N748A
	JAN 1N749A
	1N4148
	1N4384
	HP5082-2800
	HP5082-3077
(4) Switches, Lamps and Capacitors	1HS41 Microswitch (Honeywell)
	Antenna Tilt Switch (Wilcox)
	Lamps DS-1 through DS-10
	Electrolytic Capacitors 3A4-C15 and -C16

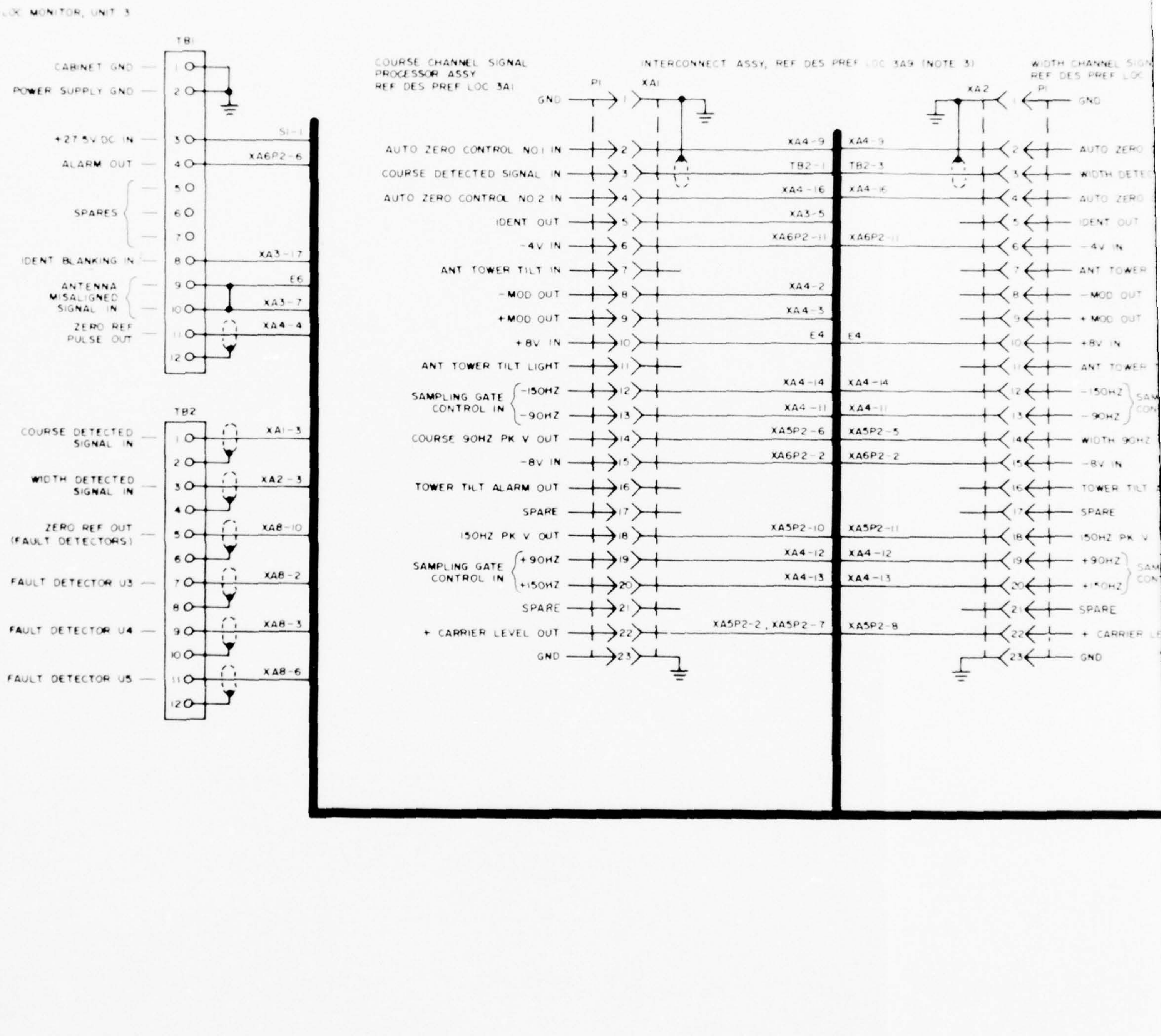
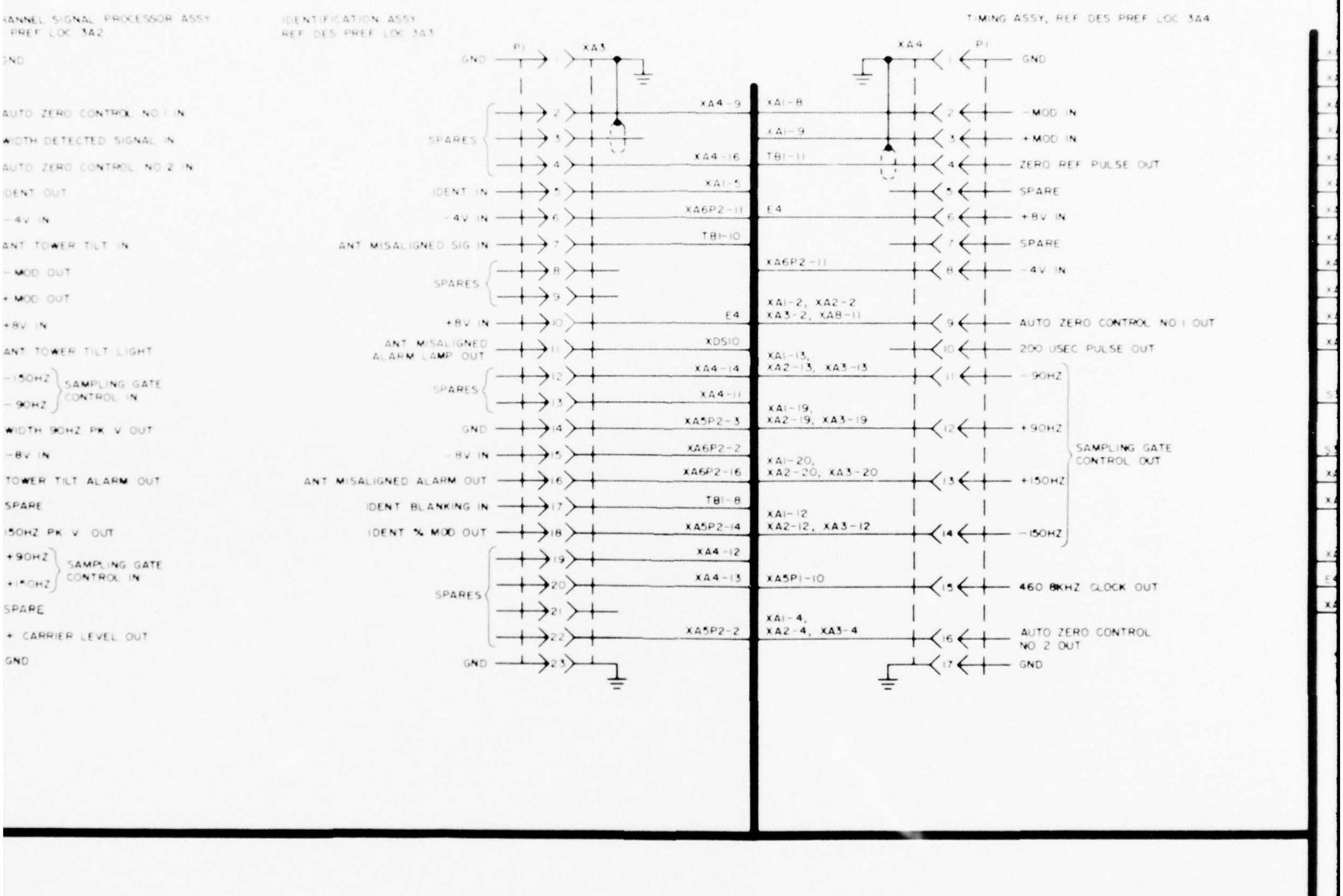
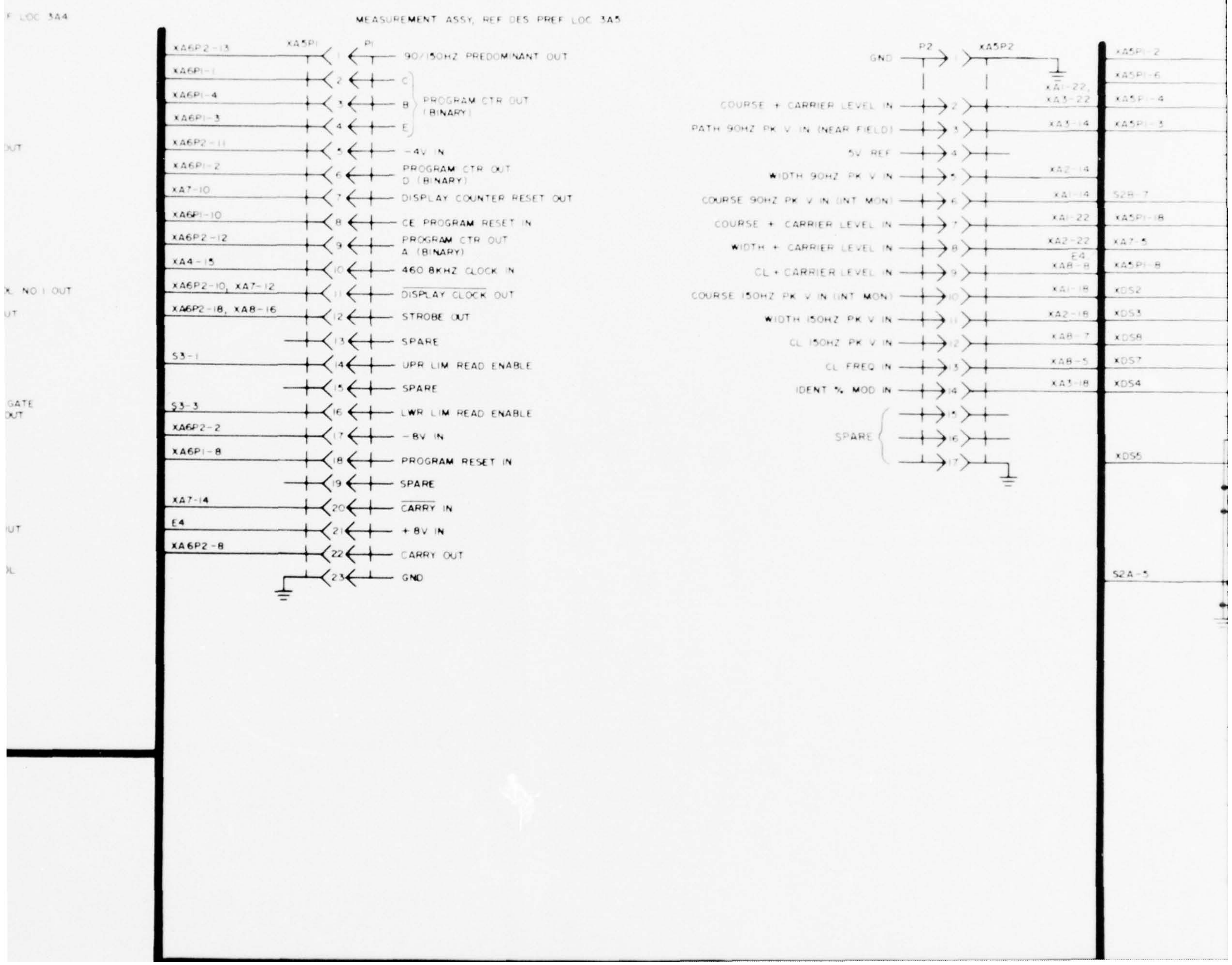
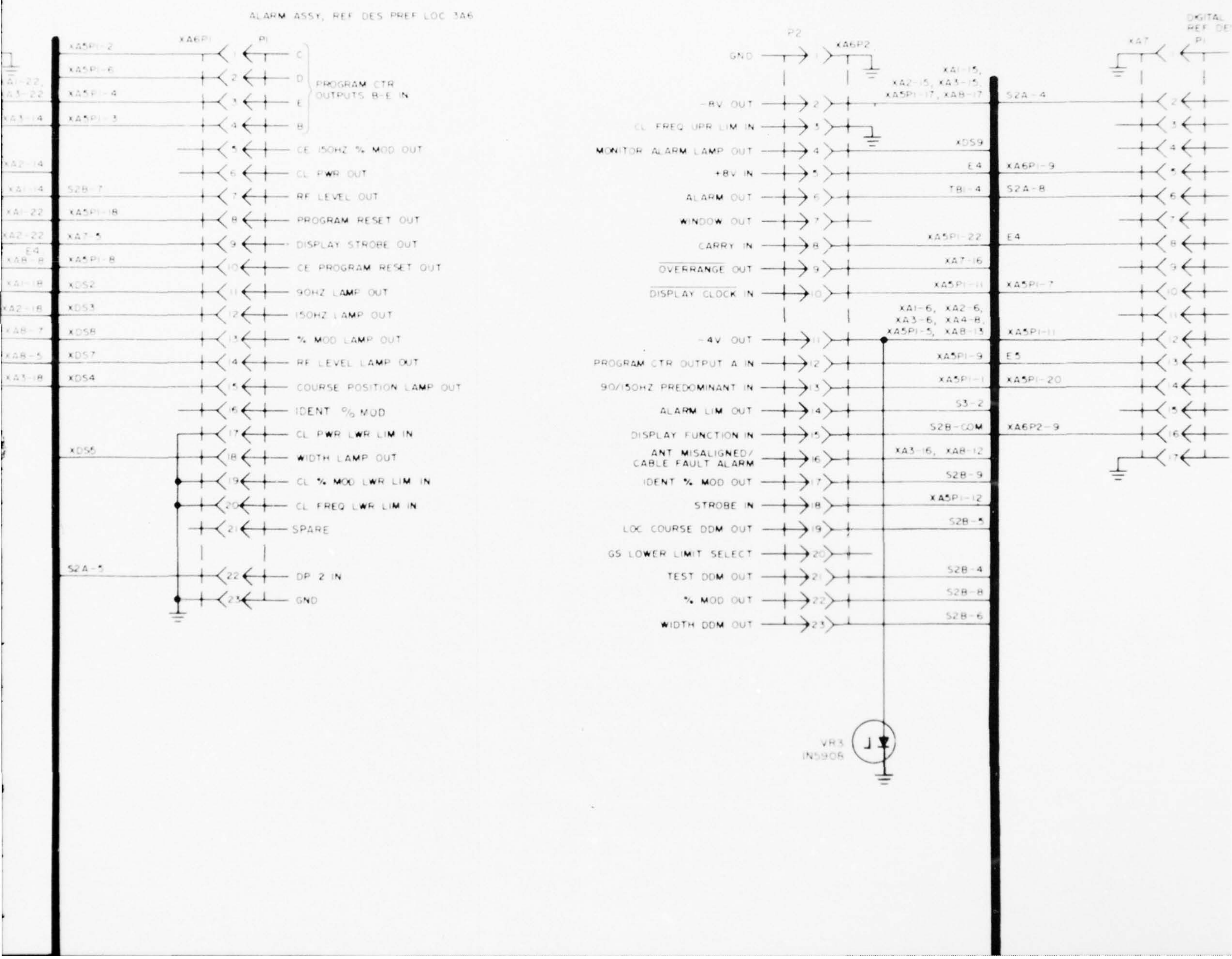


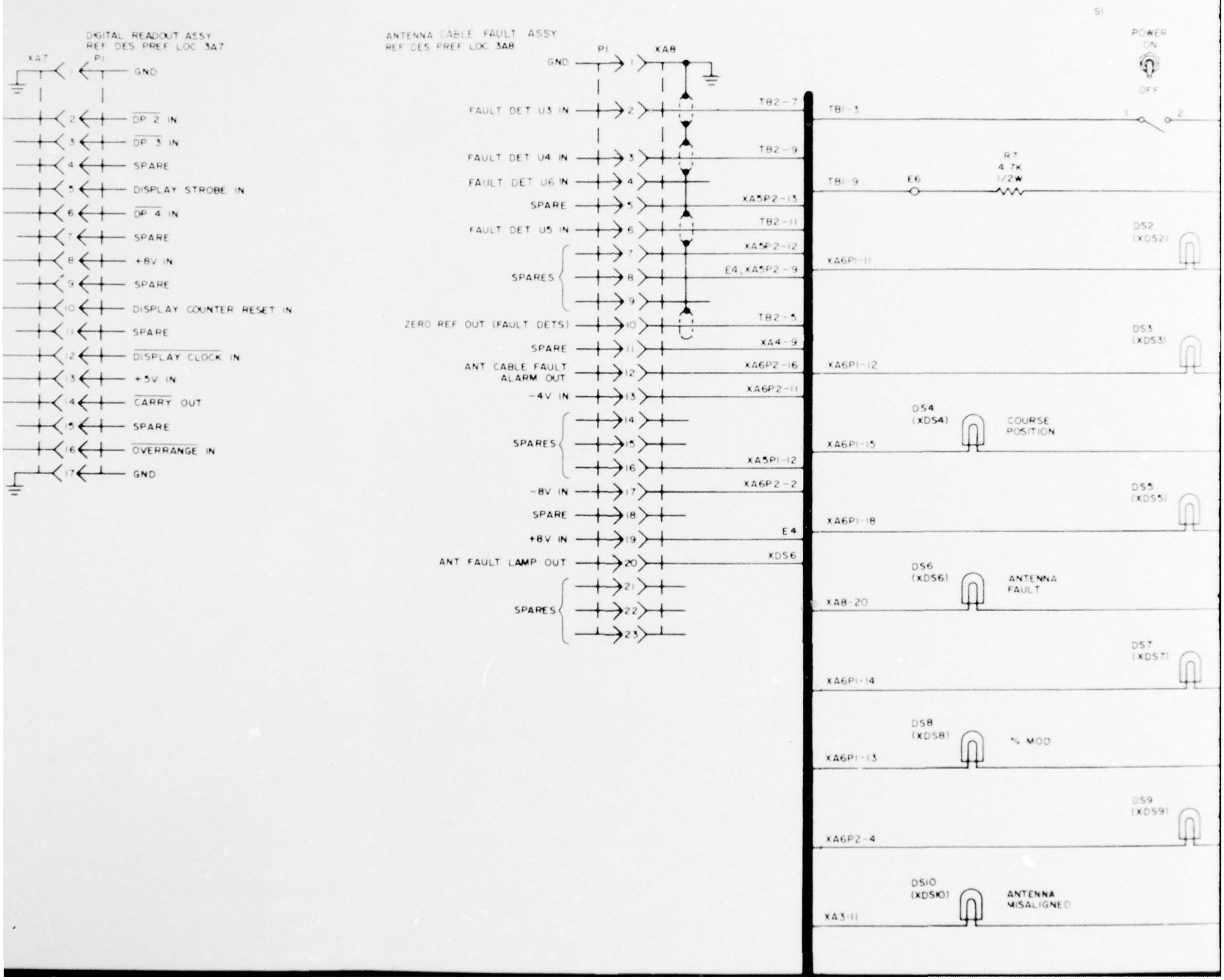
Figure 3.4-1 Localizer Monitor Chassis, Blocked Schematic



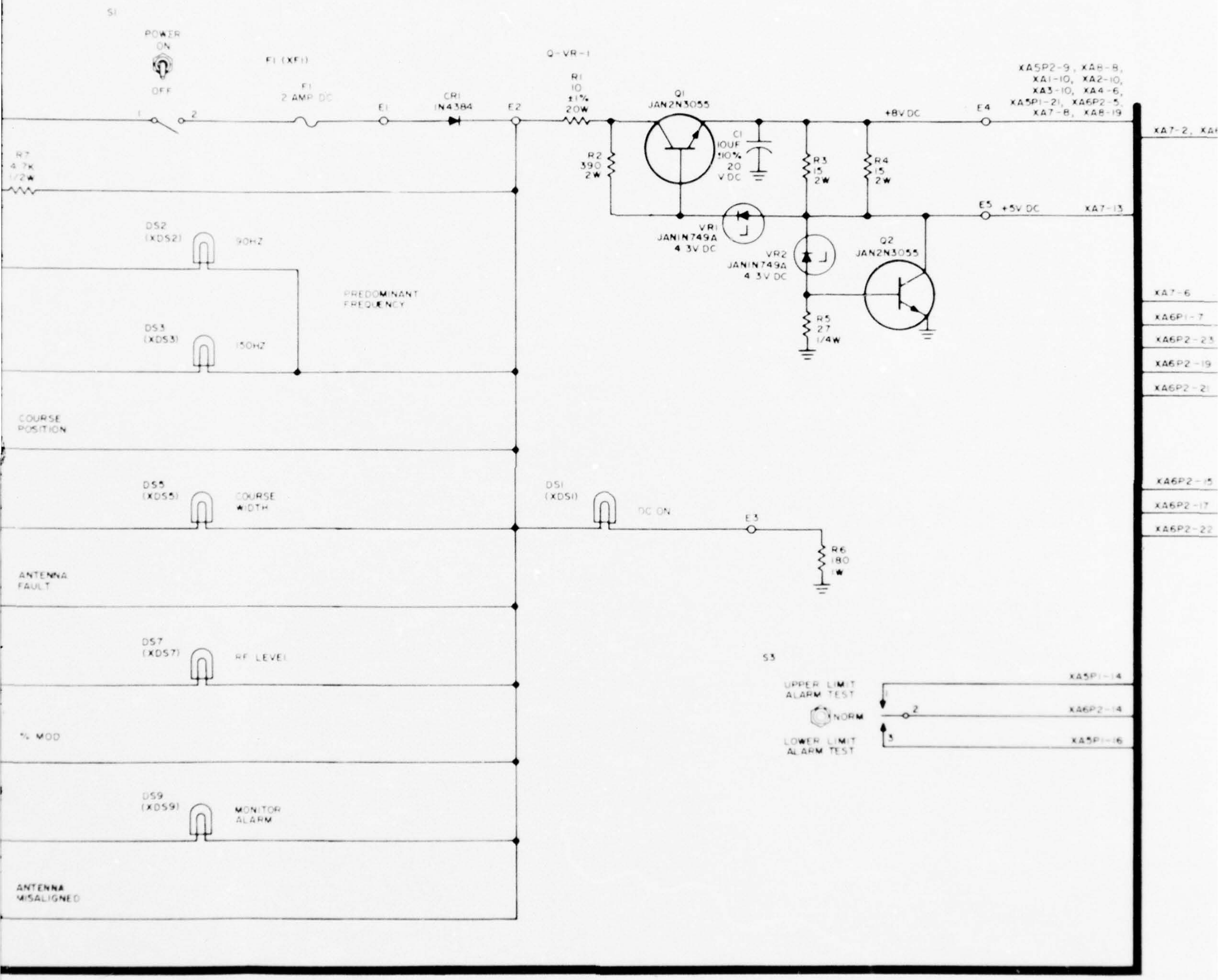
ANNEL SIGNAL PROCESSOR ASSY
PREF LOC 3A2
GND
AUTO ZERO CONTROL NO.1 IN
WIDTH DETECTED SIGNAL IN
AUTO ZERO CONTROL NO.2 IN
IDENT OUT
-4V IN
ANT TOWER TILT IN
-MOD OUT
+MOD OUT
+8V IN
ANT TOWER TILT LIGHT
-150HZ
-90HZ
SAMPLING GATE CONTROL IN
WIDTH 90HZ PK V OUT
-8V IN
TOWER TILT ALARM OUT
SPARE
150HZ PK V OUT
+90HZ
+150HZ
SAMPLING GATE CONTROL IN
SPARE
+ CARRIER LEVEL OUT
GND
IDENTIFICATION ASSY
REF DES PREF LOC 3A3
P1
XA3
GND
SPARES
IDENT IN
-4V IN
ANT MISALIGNED SIG IN
SPARES
+8V IN
ANT MISALIGNED ALARM LAMP OUT
SPARES
GND
-8V IN
ANT MISALIGNED ALARM OUT
IDENT BLANKING IN
IDENT % MOD OUT
SPARES
GND
XA4-9
XA4-16
XA1-5
XA6P2-11
TB1-10
E4
XDS10
XA4-14
XA4-11
XA5P2-3
XA6P2-2
XA6P2-16
TB1-8
XA5P2-14
XA4-12
XA4-13
XA5P2-2
XA1-8
XA1-9
TB1-11
E4
XA6P2-11
XA1-2, XA2-2
XA3-2, XA8-11
XA1-13,
XA2-13, XA3-13
XA1-19,
XA2-19, XA3-19
XA1-20,
XA2-20, XA3-20
XA1-12
XA2-12, XA3-12
XA5P1-10
XA1-4,
XA2-4, XA3-4
TIMING ASSY, REF DES PREF LOC 3A4
XA4
P1
GND
-MOD IN
+MOD IN
ZERO REF PULSE OUT
SPARE
+8V IN
SPARE
-4V IN
AUTO ZERO CONTROL NO.1 OUT
200 USEC PULSE OUT
-90HZ
+90HZ
+150HZ
-150HZ
SAMPLING GATE CONTROL OUT
460.8KHZ CLOCK OUT
AUTO ZERO CONTROL NO.2 OUT
GND


F LOC 3A4
MEASUREMENT ASSY, REF DES PREF LOC 3A5
XA5P1
P1
XA6P2-13
1
90/150HZ PREDOMINANT OUT
XA6P1-1
2
C
XA6P1-4
3
B
PROGRAM CTR OUT (BINARY)
XA6P1-3
4
E
XA6P2-11
5
-4V IN
XA6P1-2
6
PROGRAM CTR OUT D (BINARY)
XA7-10
7
DISPLAY COUNTER RESET OUT
XA6P1-10
8
CE PROGRAM RESET IN
XA6P2-12
9
PROGRAM CTR OUT A (BINARY)
XA4-15
10
460.8KHZ CLOCK IN
XA6P2-10, XA7-12
11
DISPLAY CLOCK OUT
XA6P2-18, XA8-16
12
STROBE OUT
13
SPARE
S3-1
14
UPR LIM READ ENABLE
15
SPARE
S3-3
16
LWR LIM READ ENABLE
XA6P2-2
17
-8V IN
XA6P1-8
18
PROGRAM RESET IN
19
SPARE
XA7-14
20
CARRY IN
E4
21
+8V IN
XA6P2-8
22
CARRY OUT
23
GND
OUT
L NO 1 OUT
UT
GATE OUT
UT
L
P2
XA5P2
GND
1
XA1-22, XA3-22
COURSE + CARRIER LEVEL IN
2
PATH 90HZ PK V IN (NEAR FIELD)
3
XA3-14
5V REF
4
WIDTH 90HZ PK V IN
5
XA2-14
COURSE 90HZ PK V IN (INT MON)
6
XA1-14
COURSE + CARRIER LEVEL IN
7
XA1-22
WIDTH + CARRIER LEVEL IN
8
XA2-22
E4
CL + CARRIER LEVEL IN
9
XA8-8
COURSE 150HZ PK V IN (INT MON)
10
XA1-18
WIDTH 150HZ PK V IN
11
XA2-18
CL 150HZ PK V IN
12
XA8-7
CL FREQ IN
13
XA8-5
IDENT % MOD IN
14
XA3-18
SPARE
15
16
17
XA5P1-2
XA5P1-6
XA5P1-4
XA5P1-3
S2B-7
XA5P1-18
XA7-5
XA5P1-8
XDS2
XDS3
XDS8
XDS7
XDS4
XDS5
S2A-5

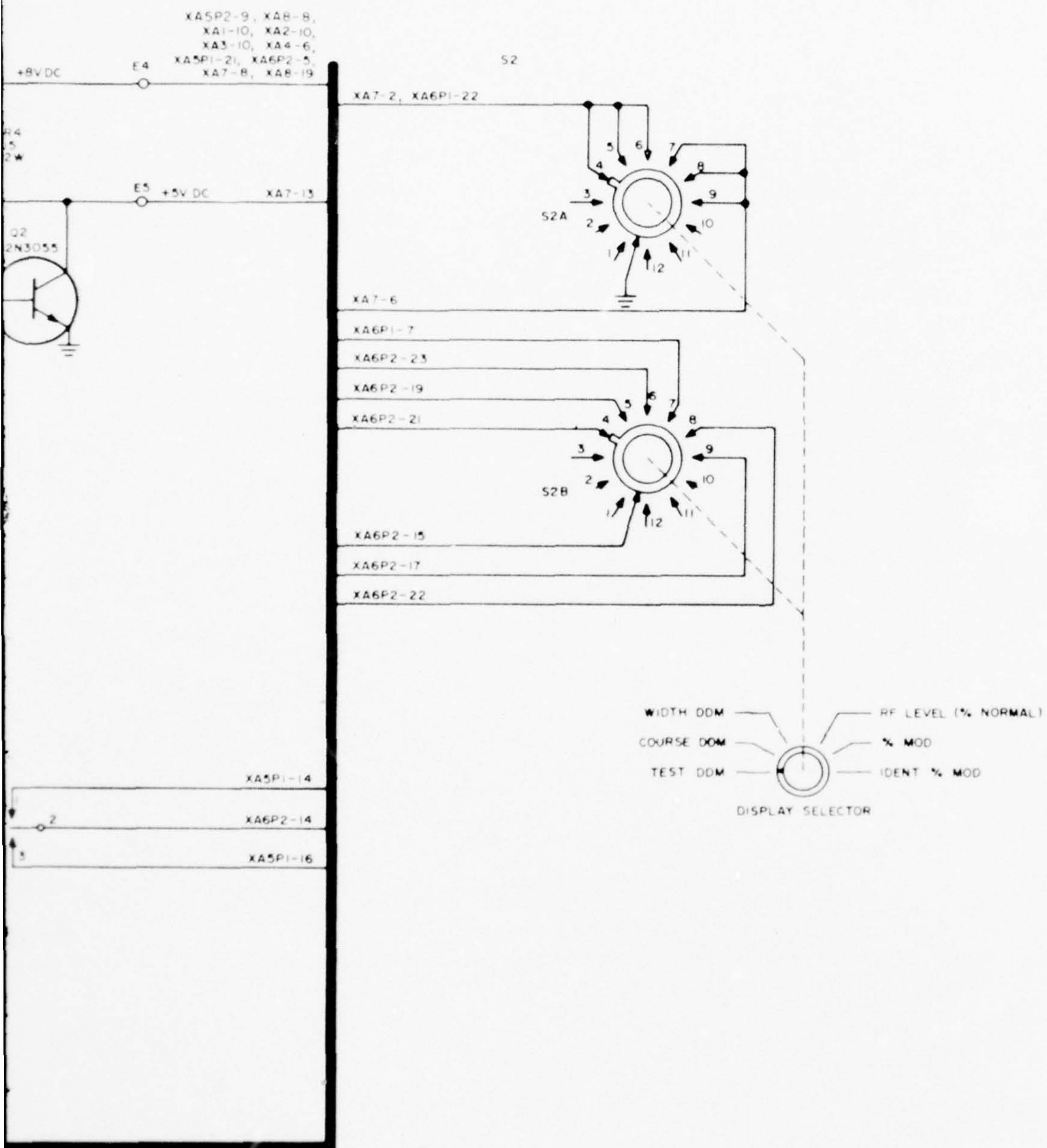

ALARM ASSY, REF DES PREF LOC 3A6
XA6P1
P1
PROGRAM CTR OUTPUTS B-E IN
CE 150HZ % MOD OUT
CL PWR OUT
RF LEVEL OUT
PROGRAM RESET OUT
DISPLAY STROBE OUT
CE PROGRAM RESET OUT
90HZ LAMP OUT
150HZ LAMP OUT
% MOD LAMP OUT
RF LEVEL LAMP OUT
COURSE POSITION LAMP OUT
IDENT % MOD
CL PWR LWR LIM IN
WIDTH LAMP OUT
CL % MOD LWR LIM IN
CL FREQ LWR LIM IN
SPARE
DP 2 IN
GND
XA5P1-2
XA5P1-6
XA5P1-4
XA5P1-3
S2B-7
XA5P1-18
XA7-5
XA5P1-8
XDS2
XDS3
XDS8
XDS7
XDS4
XDS5
S2A-5
P2
XA6P2
GND
-8V OUT
CL FREQ UPR LIM IN
MONITOR ALARM LAMP OUT
+8V IN
ALARM OUT
WINDOW OUT
CARRY IN
OVERRANGE OUT
DISPLAY CLOCK IN
-4V OUT
PROGRAM CTR OUTPUT A IN
90/150HZ PREDOMINANT IN
ALARM LIM OUT
DISPLAY FUNCTION IN
ANT MISALIGNED/
CABLE FAULT ALARM
IDENT % MOD OUT
STROBE IN
LOC COURSE DDM OUT
GS LOWER LIMIT SELECT
TEST DDM OUT
% MOD OUT
WIDTH DDM OUT
XA1-15,
XA2-15, XA3-15,
XA5P1-17, XA8-17
XDS9
E4
TB1-4
XA5P1-22
XA7-16
XA5P1-11
XA1-6, XA2-6,
XA3-6, XA4-8,
XA5P1-5, XA8-13
XA5P1-9
XA5P1-1
S3-2
S2B-COM
XA3-16, XA8-12
S2B-9
XA5P1-12
S2B-5
S2B-4
S2B-8
S2B-6
S2A-4
XA6P1-9
S2A-8
E4
XA5P1-7
XA5P1-11
E5
XA5P1-20
XA6P2-9
VR3
1N5908
XA7
DIGITAL
REF DE
P1



DIGITAL READOUT ASSY
REF DES PREF LOC 3A7
XA7
P1
GND
DP 2 IN
DP 3 IN
SPARE
DISPLAY STROBE IN
DP 4 IN
SPARE
+8V IN
SPARE
DISPLAY COUNTER RESET IN
SPARE
DISPLAY CLOCK IN
+5V IN
CARRY OUT
SPARE
OVERRANGE IN
GND
ANTENNA CABLE FAULT ASSY
REF DES PREF LOC 3A8
P1
XA8
GND
FAULT DET U3 IN
FAULT DET U4 IN
FAULT DET U6 IN
SPARE
FAULT DET U5 IN
SPARES
ZERO REF OUT (FAULT DETS)
SPARE
ANT CABLE FAULT ALARM OUT
-4V IN
SPARES
-8V IN
SPARE
+8V IN
ANT FAULT LAMP OUT
SPARES
TB2-7
TB2-9
XA5P2-13
TB2-11
XA5P2-12
E4, XA5P2-9
TB2-5
XA4-9
XA6P2-16
XA6P2-11
XA5P1-12
XA6P2-2
E4
XDS6
S1
POWER
ON
OFF
TB1-3
TB1-9
E6
R7
4.7K
1/2W
DS2
(XDS2)
XA6P1-11
DS3
(XDS3)
XA6P1-12
DS4
(XDS4)
COURSE POSITION
XA6P1-15
DS5
(XDS5)
XA6P1-18
DS6
(XDS6)
ANTENNA FAULT
XA8-20
DS7
(XDS7)
XA6P1-14
DS8
(XDS8)
% MOD
XA6P1-13
DS9
(XDS9)
XA6P2-4
DS10
(XDS10)
ANTENNA MISALIGNED
XA3-11


S1
POWER
ON
OFF
F1 (XF1)
F1
2 AMP DC
E1
CR1
1N4384
E2
Q-VR-1
R1
10
±1%
20W
Q1
JAN2N3055
C1
10UF
±10%
20
VDC
R2
390
2W
R3
15
2W
R4
15
2W
+8VDC
E4
XA5P2-9, XA8-8,
XA1-10, XA2-10,
XA3-10, XA4-6,
XA5P1-21, XA6P2-5,
XA7-8, XA8-19
E5
+5V DC
XA7-13
VR1
JAN1N749A
4.3V DC
VR2
JAN1N749A
4.3V DC
Q2
JAN2N3055
R5
27
1/4W
R7
4.7K
1/2W
DS2
(XDS2)
90HZ
PREDOMINANT
FREQUENCY
DS3
(XDS3)
150HZ
COURSE
POSITION
DS5
(XDS5)
COURSE
WIDTH
DS1
(XDS1)
DC ON
E3
R6
180
1W
ANTENNA
FAULT
DS7
(XDS7)
RF LEVEL
S3
UPPER LIMIT
ALARM TEST
NORM
LOWER LIMIT
ALARM TEST
XA5P1-14
XA6P2-14
XA5P1-16
% MOD
DS9
(XDS9)
MONITOR
ALARM
ANTENNA
MISALIGNED
XA7-6
XA6P1-7
XA6P2-23
XA6P2-19
XA6P2-21
XA6P2-15
XA6P2-17
XA6P2-22

6



NOTES

1. UNLESS OTHERWISE SPECIFIED
   A. RESISTANCE VALUES ARE IN OHMS, ±5%
2. PREFIX ALL CHASSIS REFERENCE DESIGNATORS WITH LOC 3
3. FOR BETTER READABILITY, PREFIX A9 HAS BEEN OMITTED FROM ALL ADDRESSES TO CONNECTORS ON INTERCONNECT ASSY A9

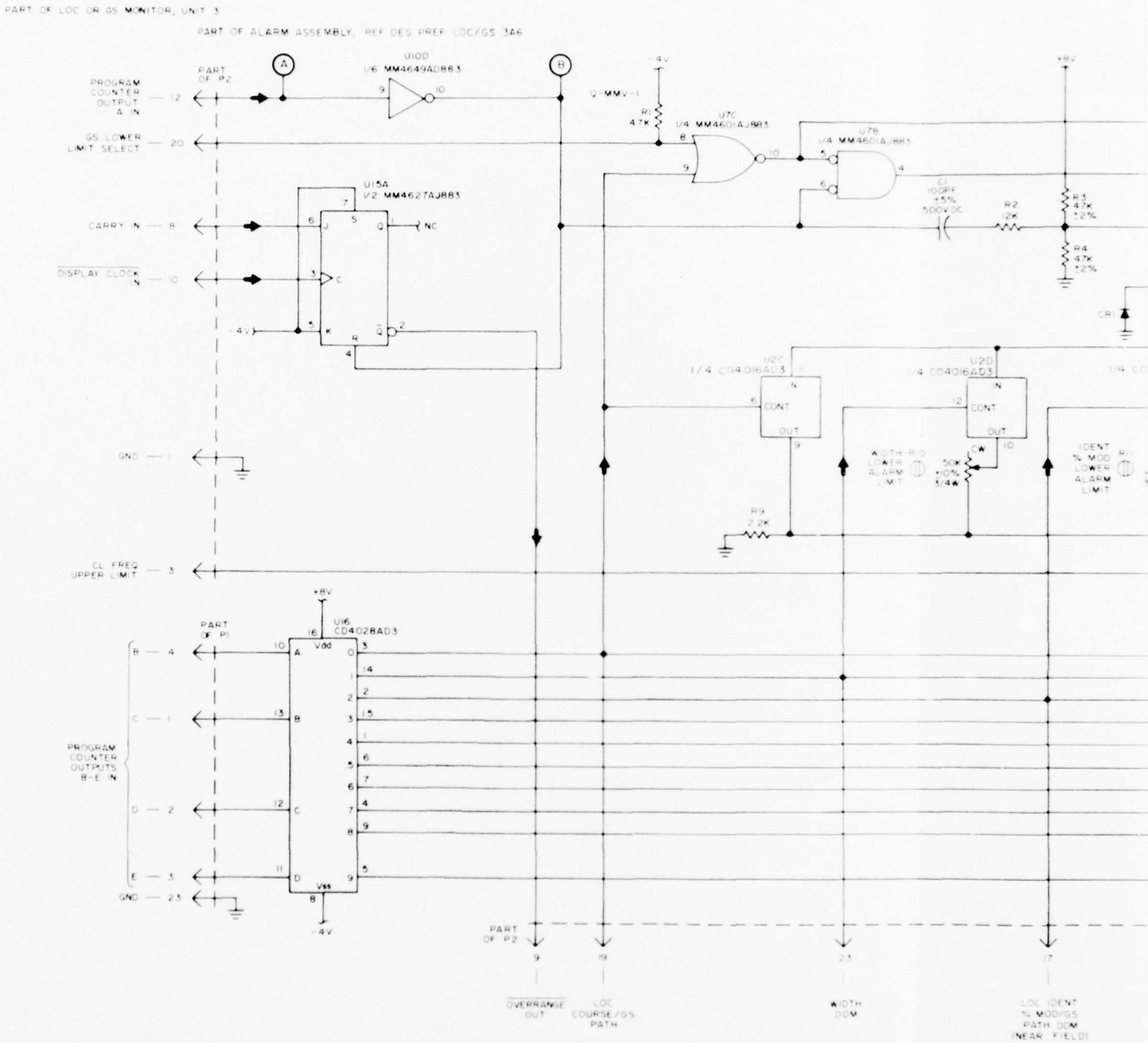
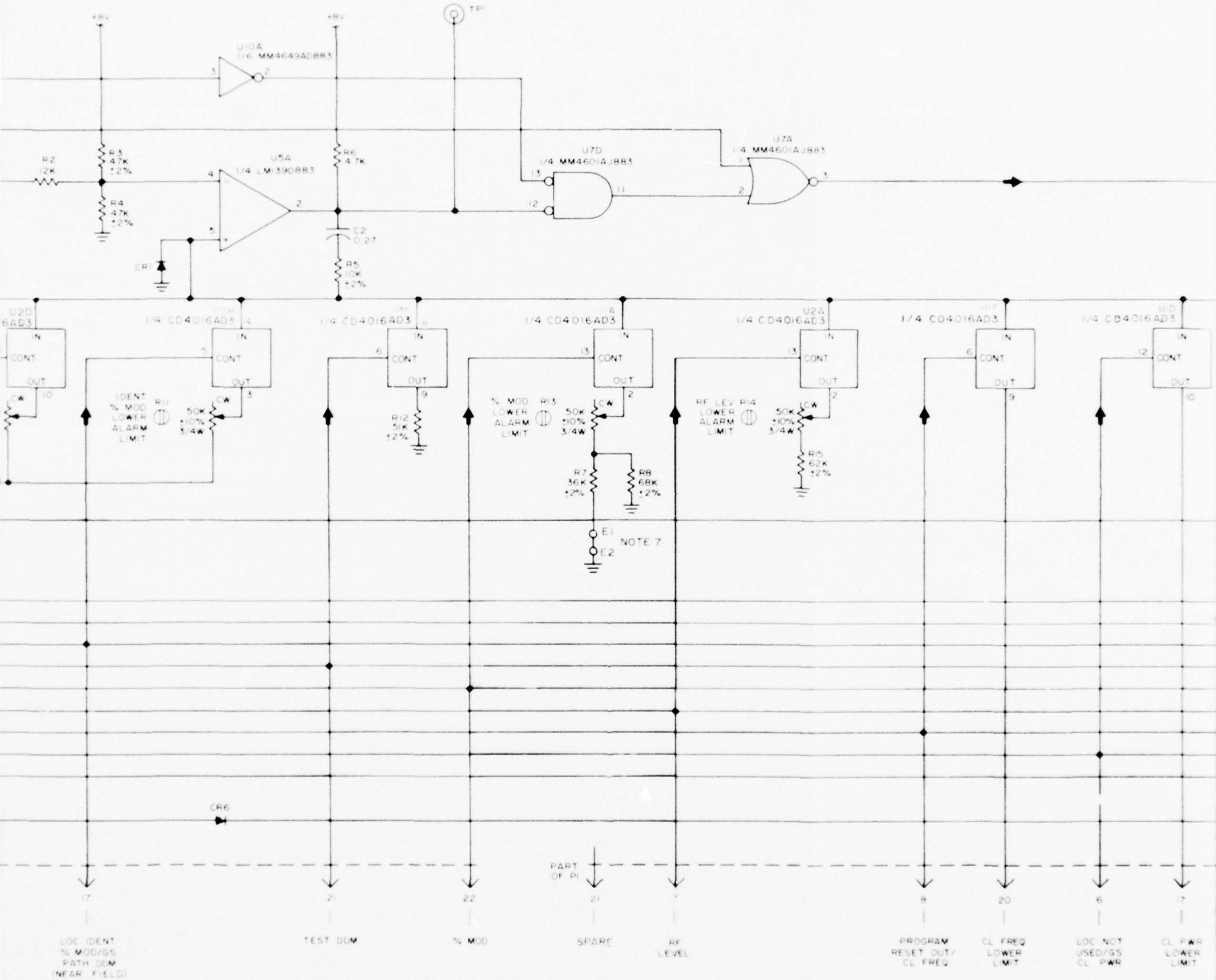
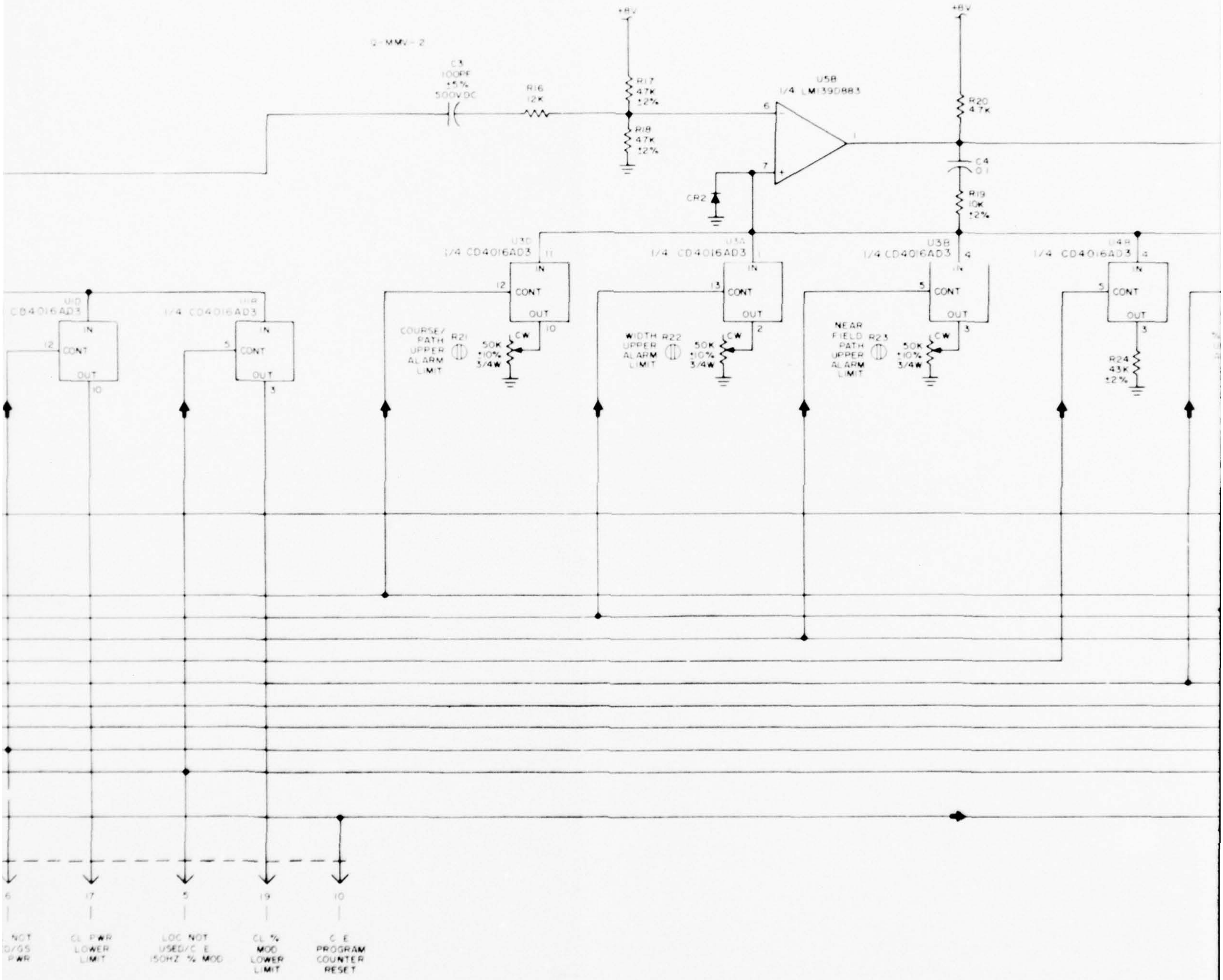


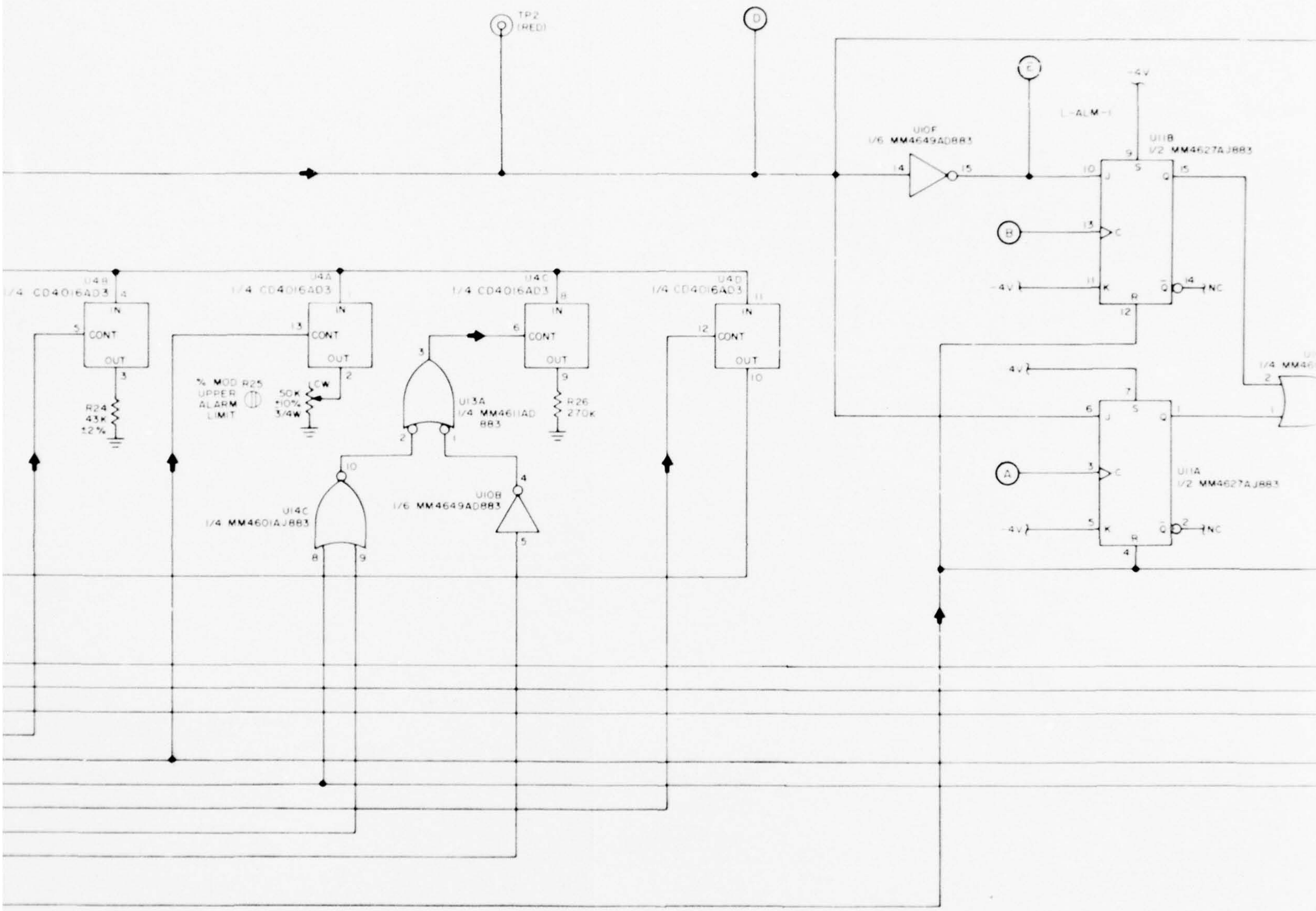
Figure 3.4-2A Alarm Assembly, Blocked Schematic (Sheet 1 of 2)



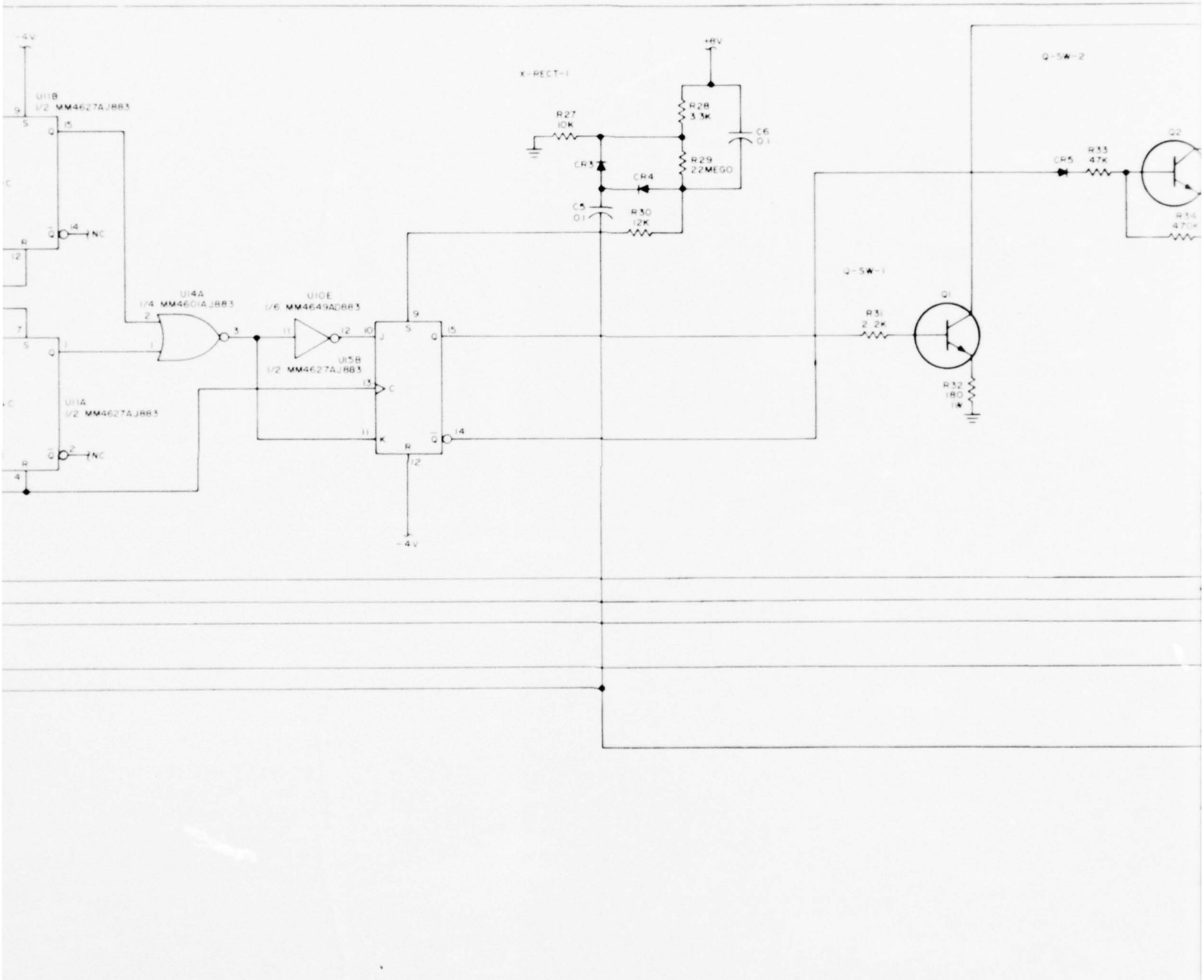
+8V
U10A
1/6 MM4649AD883
TP1
U7D
1/4 MM4601AJ883
U7A
1/4 MM4601AJ883
R2
12K
R3
47K
±2%
R4
47K
±2%
U5A
1/4 LM139D883
R6
4.7K
C2
0.27
R5
10K
±2%
CR1
1/4 CD4016AD3
IN
CONT
OUT
CW
IDENT
% MOD
LOWER
ALARM
LIMIT
R11
50K
±10%
3/4W
R12
51K
±2%
% MOD
LOWER
ALARM
LIMIT
R13
RF LEV R14
LOWER
ALARM
LIMIT
R7
36K
±2%
R8
68K
±2%
R15
62K
±2%
E1
E2
NOTE 7
CR6
PART
OF P1
LOC IDENT
% MOD/GS
PATH DDM
(NEAR FIELD)
TEST DDM
% MOD
SPARE
RF
LEVEL
PROGRAM
RESET OUT/
CL FREQ
CL FREQ
LOWER
LIMIT
LOC NOT
USED/GS
CL PWR
CL PWR
LOWER
LIMIT



Q-MMV-2
C3
100PF
±5%
500VDC
R16
12K
+8V
R17
47K
±2%
R18
47K
±2%
U5B
1/4 LM139D883
CR2
+8V
R20
4.7K
C4
0.1
R19
10K
±2%
U3D
1/4 CD4016AD3
U3A
1/4 CD4016AD3
U3B
1/4 CD4016AD3
U4B
1/4 CD4016AD3
U1D
CD4016AD3
U1B
1/4 CD4016AD3
IN
CONT
OUT
CW
COURSE/
PATH
UPPER
ALARM
LIMIT
R21
50K
±10%
3/4W
WIDTH
UPPER
ALARM
LIMIT
R22
50K
±10%
3/4W
NEAR
FIELD
PATH
UPPER
ALARM
LIMIT
R23
50K
±10%
3/4W
R24
43K
±2%
CL PWR
LOWER
LIMIT
LOC NOT
USED/C E
150HZ % MOD
CL %
MOD
LOWER
LIMIT
C E
PROGRAM
COUNTER
RESET

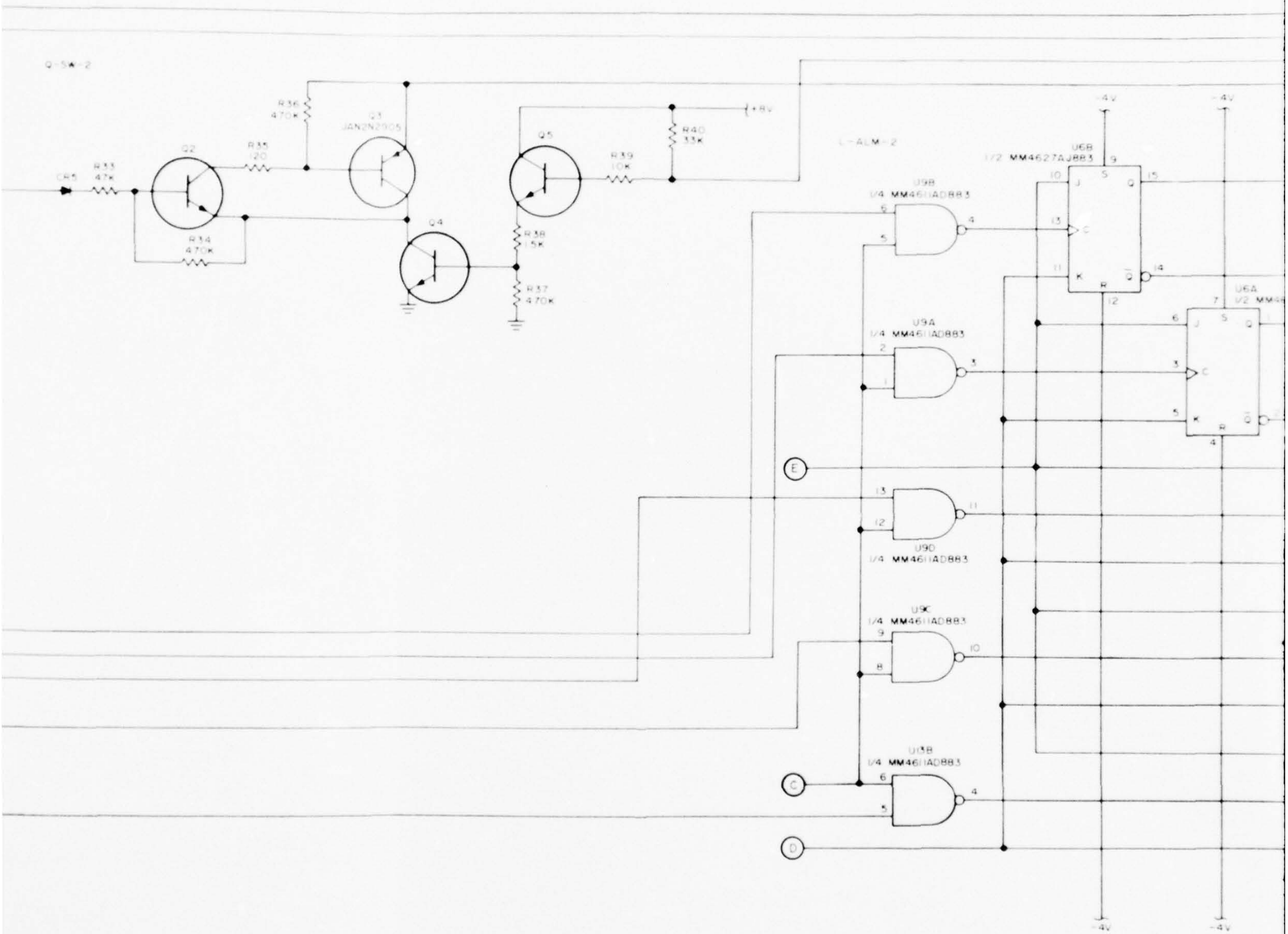

TP2 (RED)
D
E
-4V
(-ALM-)
U10F 1/6 MM4649AD883
U11B 1/2 MM4627AJ883
B
A
U4B 1/4 CD4016AD3
U4A 1/4 CD4016AD3
U4C 1/4 CD4016AD3
U4D 1/4 CD4016AD3
IN
CONT
OUT
R24 43K ±2%
% MOD R25 UPPER ALARM LIMIT
50K ±10% 3/4W
CW
U13A 1/4 MM4611AD 883
R26 270K
U14C 1/4 MM4601AJ883
U10B 1/6 MM4649AD883
U11A 1/2 MM4627AJ883
NC
4V

4

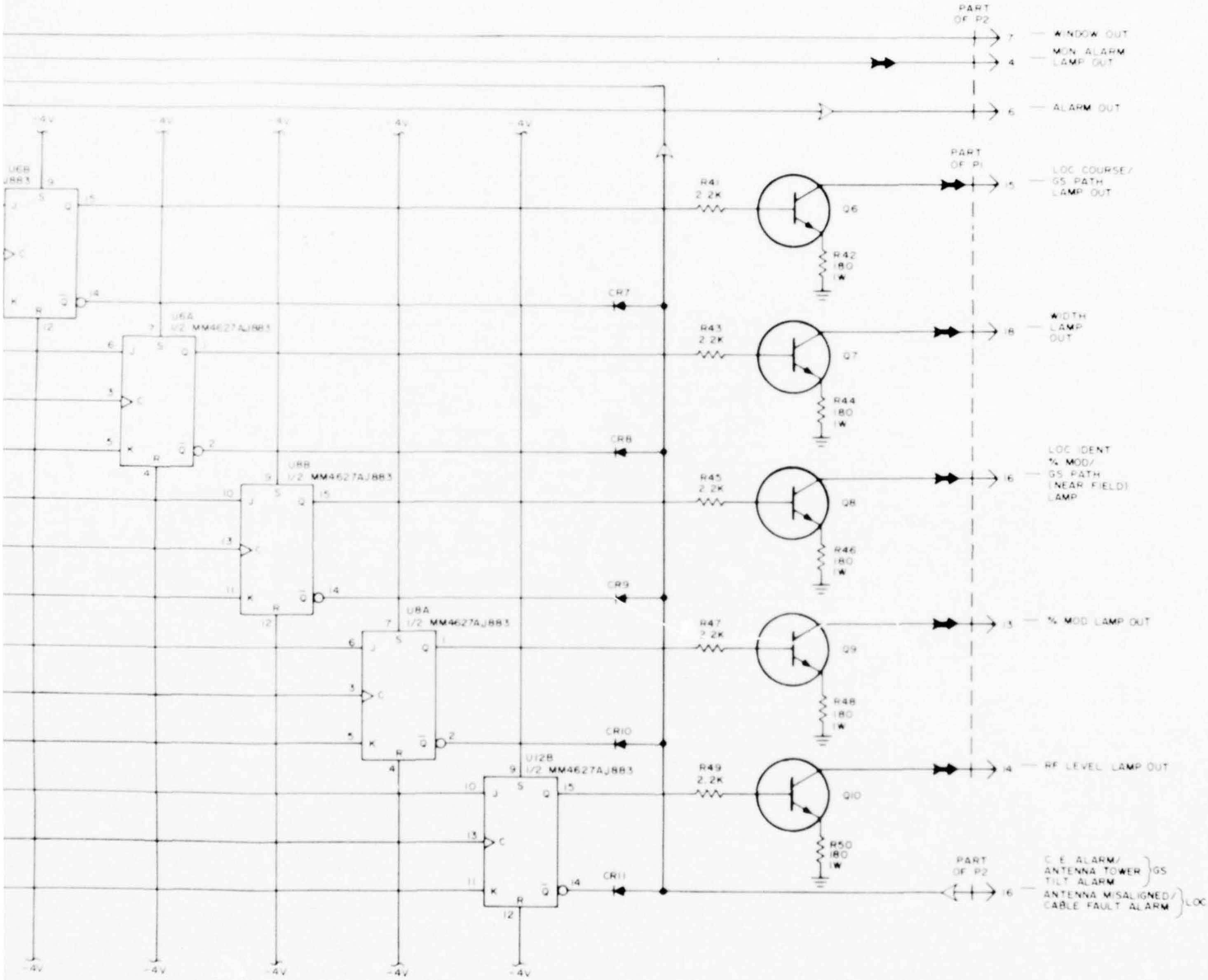


-4V
U11B
1/2 MM4627AJ883
U14A
1/4 MM4601AJ883
U10E
1/6 MM4649AD883
U15B
1/2 MM4627AJ883
U11A
1/2 MM4627AJ883
NC
-4V
X-RECT-1
+8V
R27
10K
R28
3.3K
R29
22MEGΩ
C6
0.1
CR3
CR4
C5
0.1
R30
12K
Q-SW-2
CR5
R33
47K
Q2
R34
470K
Q-SW-1
R31
2.2K
Q1
R32
180
1W

5


Q-SW-2
R36
470K
Q3
JAN2N2905
+8V
R40
33K
L-ALM-2
Q2
R35
120
Q5
R39
10K
CR5
R33
47K
R34
470K
Q4
R38
1.5K
R37
470K
U9B
1/4 MM4611AD883
U6B
1/2 MM4627AJ883
-4V
U6A
U9A
1/4 MM4611AD883
E
U9D
1/4 MM4611AD883
U9C
1/4 MM4611AD883
U13B
1/4 MM4611AD883
C
D
-4V

4


PART OF P2
WINDOW OUT
MON ALARM LAMP OUT
ALARM OUT
PART OF P1
LOC COURSE/ GS PATH LAMP OUT
WIDTH LAMP OUT
LOC IDENT % MOD/ GS PATH (NEAR FIELD) LAMP
% MOD LAMP OUT
RF LEVEL LAMP OUT
C.E. ALARM/ ANTENNA TOWER TILT ALARM
GS
ANTENNA MISALIGNED/ CABLE FAULT ALARM
LOC
U6A 1/2 MM4627AJ883
U8B 1/2 MM4627AJ883
U8A 1/2 MM4627AJ883
U12B 1/2 MM4627AJ883
R41 2.2K
R43 2.2K
R45 2.2K
R47 2.2K
R49 2.2K
R42 180 1W
R44 180 1W
R46 180 1W
R48 180 1W
R50 180 1W
Q6
Q7
Q8
Q9
Q10
CR7
CR8
CR9
CR10
CR11
-4V

1

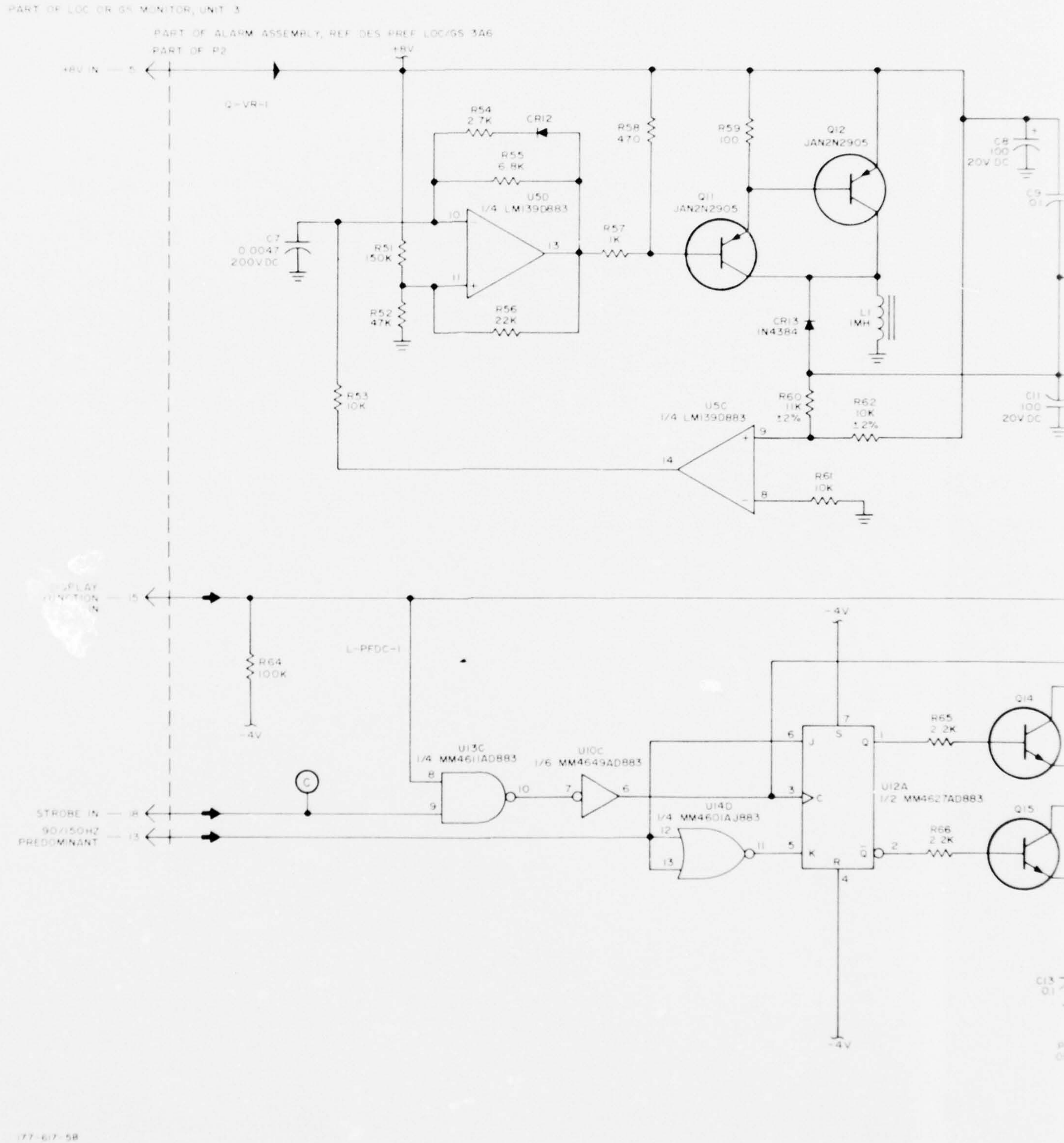
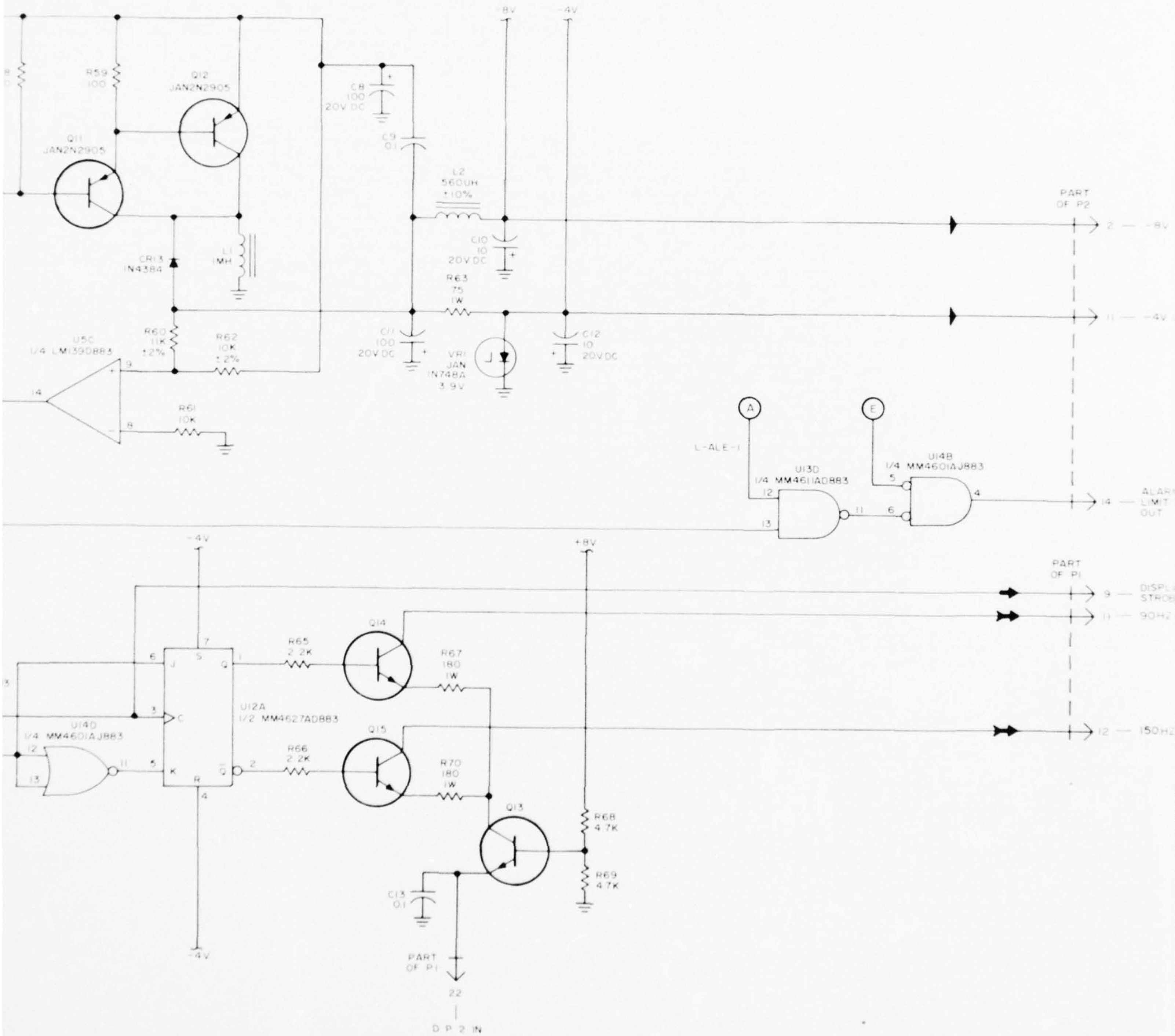
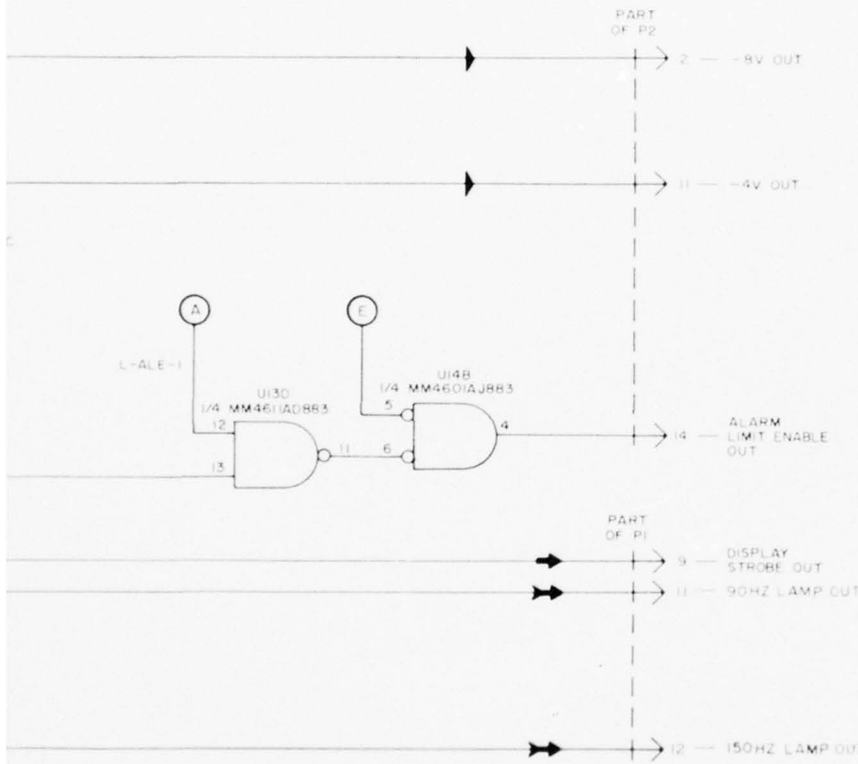


Figure 3.4-2B Alarm Assembly, Blocked Schematic (Sheet 2 of 2)



ic (Sheet 2 of 2)

2



NOTES:

1. UNLESS OTHERWISE SPECIFIED
   A. RESISTANCE VALUES ARE IN OHMS, ±5%, AND 1/4W
   B. CAPACITANCE VALUES ARE IN MICROFARADS, ±10%, AND 100V DC
2. UNLESS OTHERWISE SPECIFIED TRANSISTORS ARE TYPE JAN2N1711
3. UNLESS OTHERWISE SPECIFIED DIODES ARE TYPE JAN1N4148
4. INTEGRATED CIRCUIT PIN CONNECTIONS NOT SHOWN ON THE SCHEMATIC ARE

IC	V+, Vcc, Vdd (+8V) PIN	Vss (-4V) PIN
U1, U2, U3, U4, U7, U9, U13, U14	14	7
U5	3	12
U6, U8, U11, U12, U15	16	8
U10	1	8

5. PREFIX REFERENCE DESIGNATORS WITH LOC/GS 3A6
6. LINES TERMINATED BY IDENTICAL CIRCLED LETTERS ARE COMMON. EXAMPLE: ALL POINTS IDENTIFIED BY (A) ARE, ELECTRICALLY, THE SAME POINT
7. REMOVE JUMPER BETWEEN E1 AND E2 FOR GLIDE SLOPE INSTALLATION

3

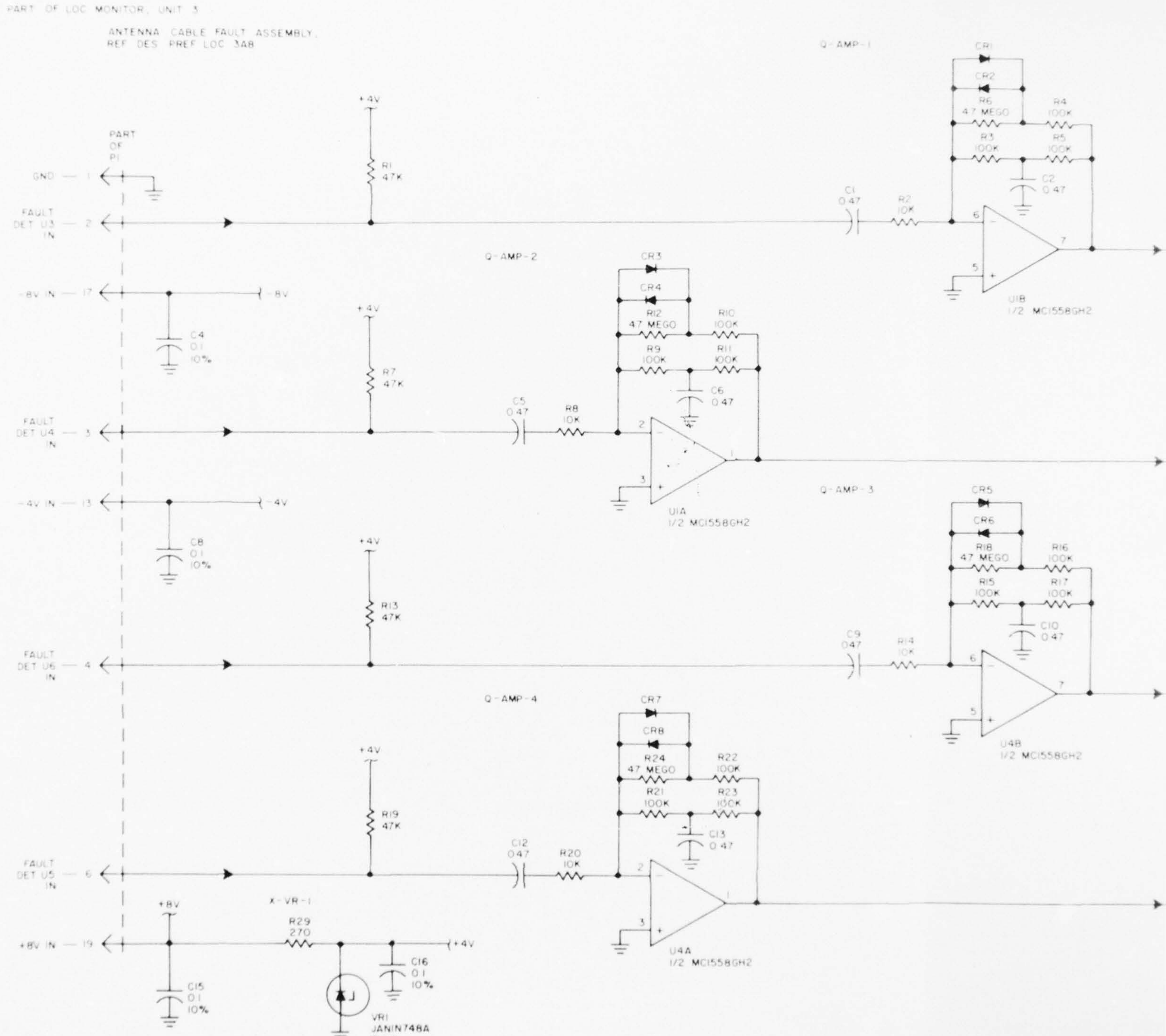
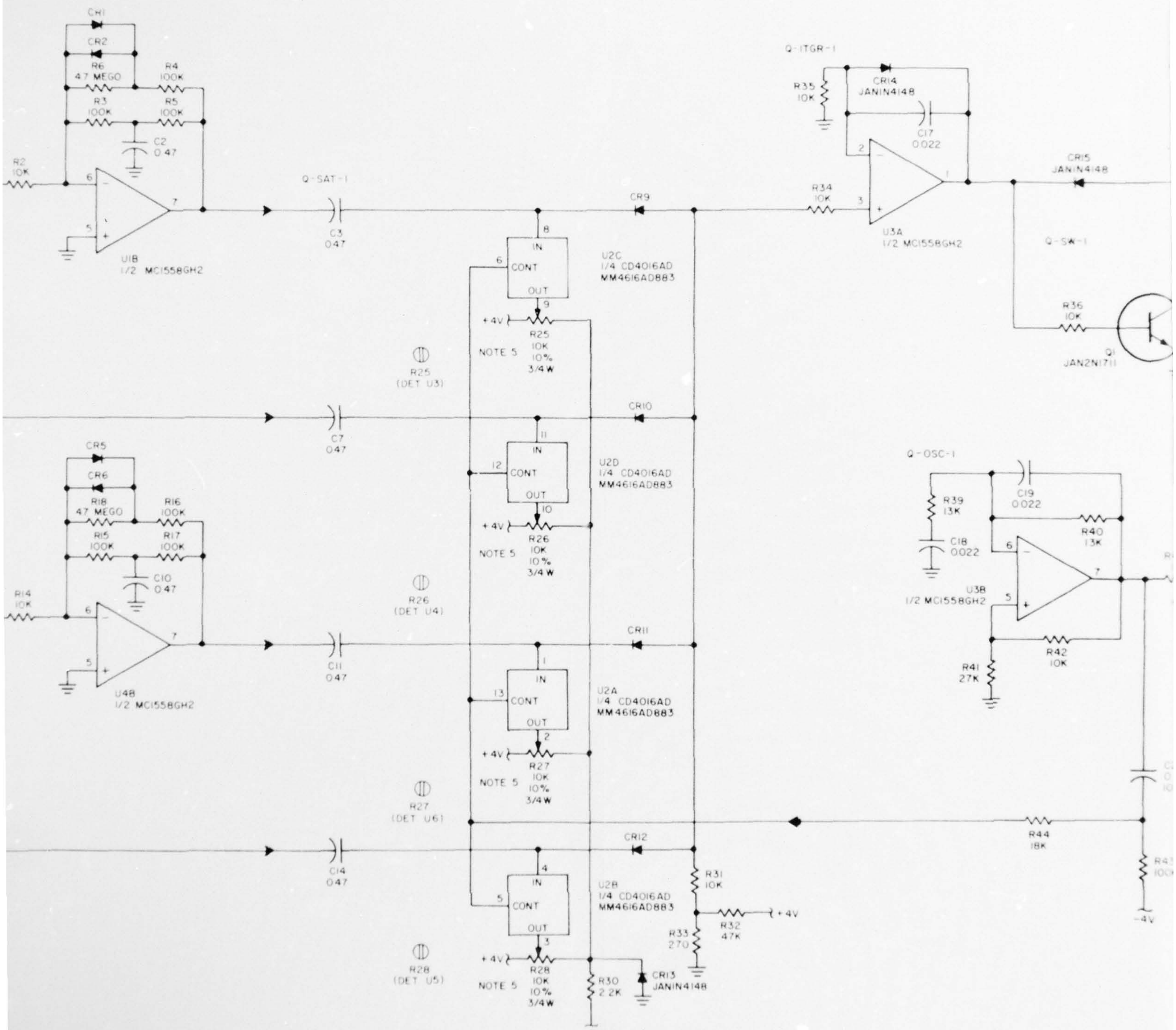
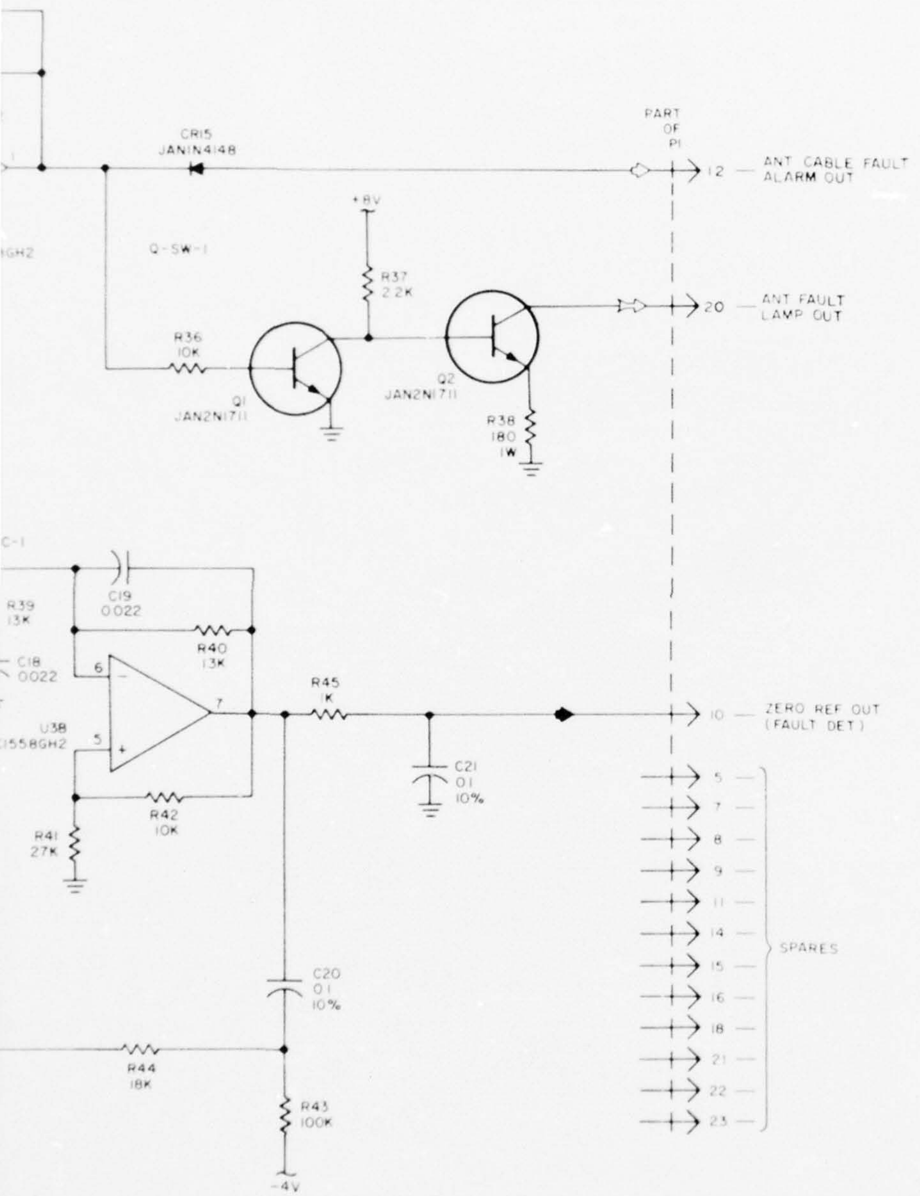


Figure 3.4-3 Antenna Cable Fault Assembly, Blocked Schematic



CR1
CR2
R6 4.7 MEGO
R4 100K
R3 100K
R5 100K
C2 0.47
R2 10K
U1B 1/2 MC1558GH2
Q-SAT-1
C3 0.47
CR9
U2C 1/4 CD4016AD MM4616AD883
R25 10K 10% 3/4W
NOTE 5
R25 (DET U3)
CR10
C7 0.47
U2D 1/4 CD4016AD MM4616AD883
CR5
CR6
R18 4.7 MEGO
R16 100K
R15 100K
R17 100K
C10 0.47
R14 10K
U4B 1/2 MC1558GH2
R26 10K 10% 3/4W
R26 (DET U4)
CR11
C11 0.47
U2A 1/4 CD4016AD MM4616AD883
R27 10K 10% 3/4W
R27 (DET U6)
CR12
C14 0.47
U2B 1/4 CD4016AD MM4616AD883
R28 10K 10% 3/4W
R28 (DET U5)
R30 2.2K
CR13 JAN1N4148
-8V
R31 10K
R32 47K
R33 270
+4V
Q-ITGR-1
R35 10K
CR14 JAN1N4148
C17 0.022
R34 10K
U3A 1/2 MC1558GH2
CR15 JAN1N4148
Q-SW-1
R36 10K
Q1 JAN2N1711
Q-OSC-1
R39 13K
C19 0.022
C18 0.022
R40 13K
U3B 1/2 MC1558GH2
R42 10K
R41 27K
R44 18K
-4V

2



NOTES

1 UNLESS OTHERWISE SPECIFIED
   A RESISTANCE VALUES ARE IN OHMS, 1/4W, AND ±5%
   B CAPACITANCE VALUES ARE IN MICROFARADS, 100V DC, AND ±5%

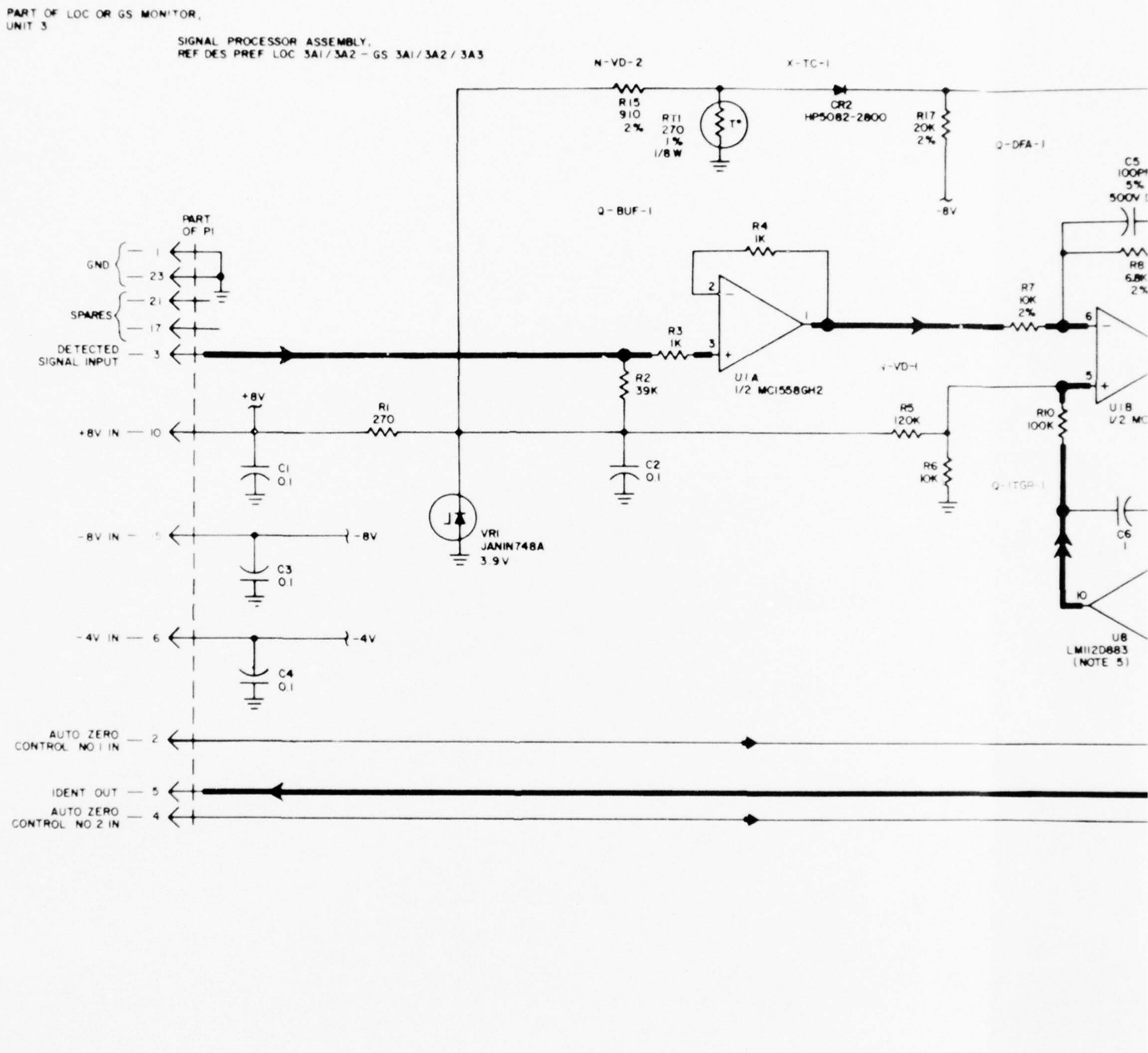
2 DIODES ARE TYPE JAN1N3595 UNLESS OTHERWISE INDICATED

3 INTEGRATED CIRCUIT PIN CONNECTIONS NOT SHOWN ON THE SCHEMATIC ARE

IC	$V+/V_{DD}$ (+8V)	V_{SS} (-4V)	V- (-8V)
U1, U4, U3	8		4
U2	14	7	

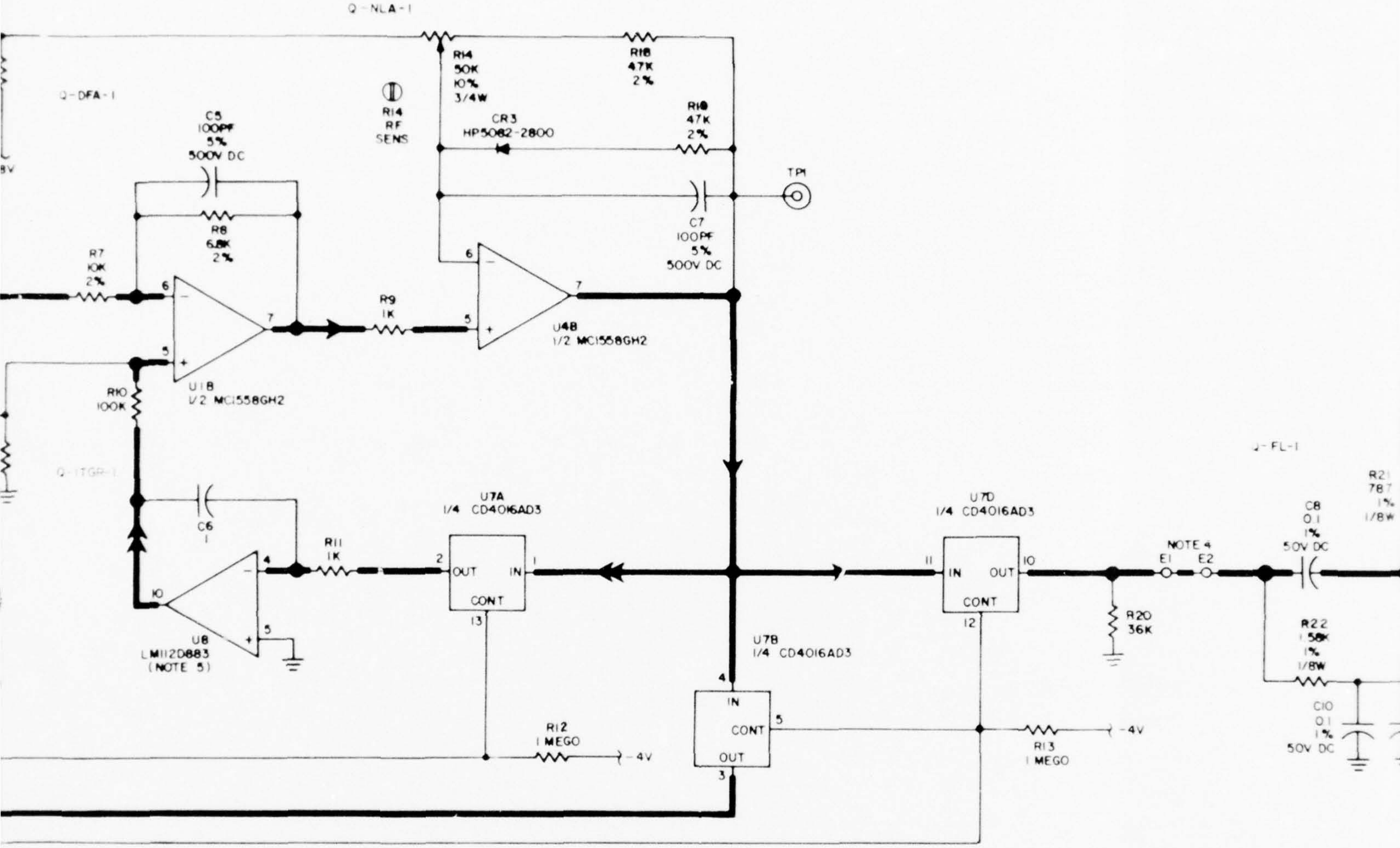
4 PREFIX REFERENCE DESIGNATORS WITH LOC 3A8

5 (DET U3) R25, (DET U4) R26, (DET U6) R27, AND (DET U5) R28 ARE ALL "ANT CABLE FAULT ALARM THRESHOLD" CONTROLS AND ARE SO LABELED ON THE EQUIPMENT

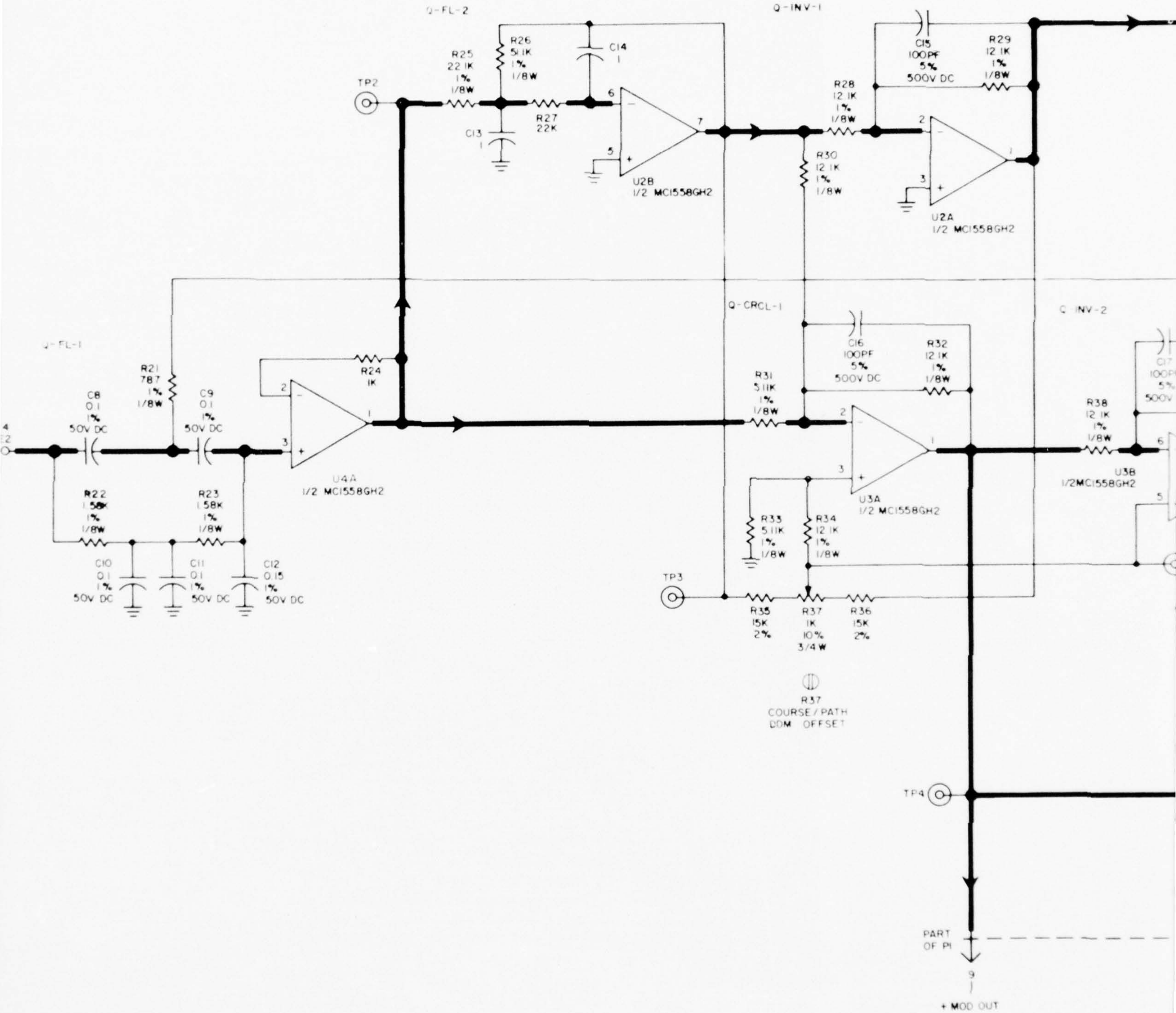


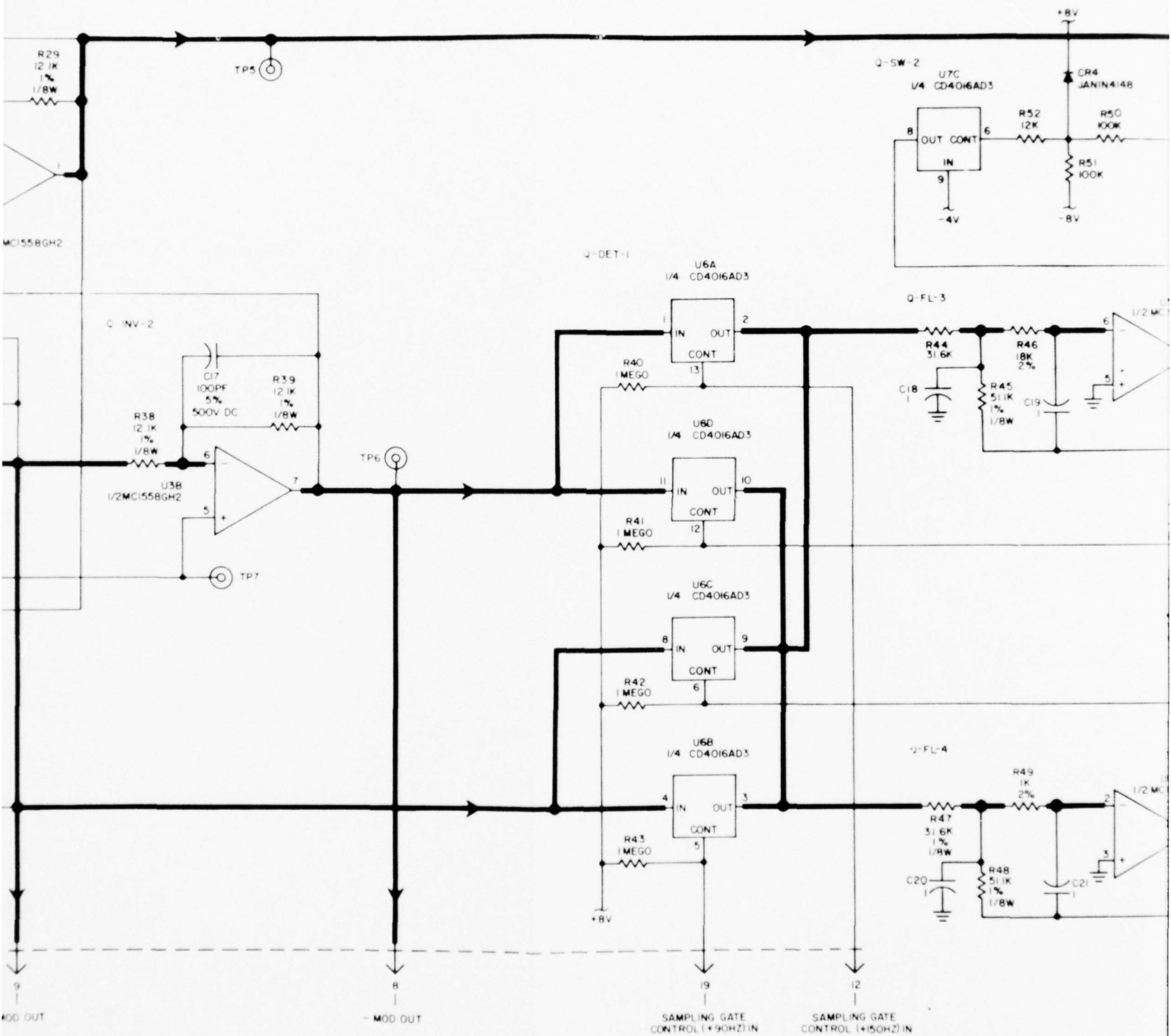
177-613-5

Figure 3.4-4 Signal Processor Assembly, Blocked Schematic

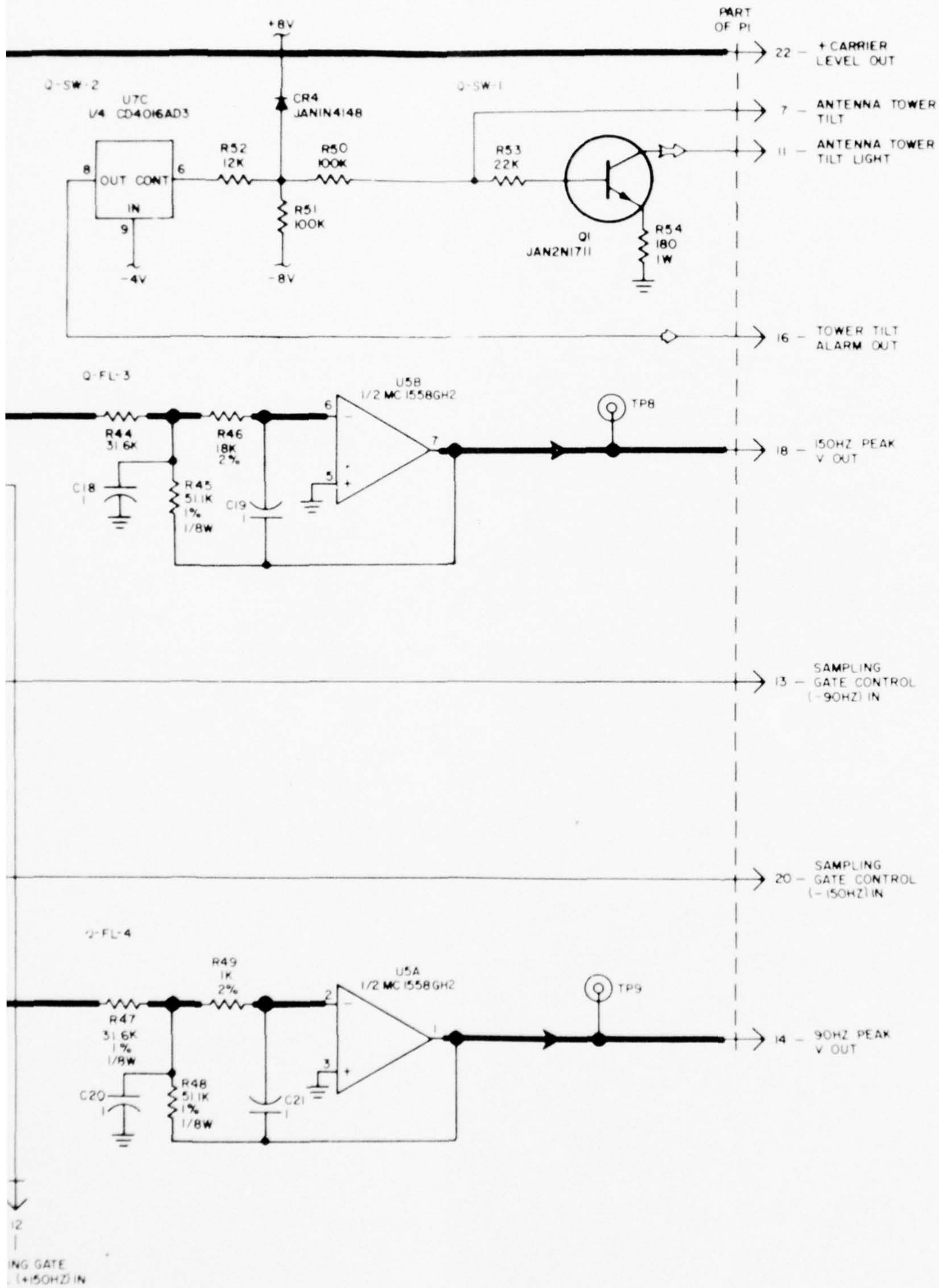


Q-NLA-1
Q-DFA-1
R14 50K 10% 3/4W
R18 47K 2%
R14 RF SENS
CR3 HP5082-2800
R19 47K 2%
C5 100PF 5% 500V DC
R8 6.8K 2%
TP1
C7 100PF 5% 500V DC
R7 10K 2%
R9 1K
U4B 1/2 MC1558GH2
U1B 1/2 MC1558GH2
R10 100K
Q-ITGR-1
C6 1
U7A 1/4 CD4016AD3
U7D 1/4 CD4016AD3
R11 1K
OUT IN CONT
NOTE 4 E1 E2
U8 LM112D883 (NOTE 5)
R20 36K
U7B 1/4 CD4016AD3
R12 1 MEGO -4V
R13 1 MEGO -4V
Q-FL-1
R21 787 1% 1/8W
C8 0.1 1% 50V DC
R22 1.58K 1% 1/8W
C10 0.1 1% 50V DC


Q-FL-2
Q-INV-1
Q-FL-1
Q-CRCL-1
Q-INV-2
TP2
TP3
TP4
R21 787 1% 1/8W
R22 1.58K 1% 1/8W
R23 1.58K 1% 1/8W
R24 1K
R25 22.1K 1% 1/8W
R26 5.1K 1% 1/8W
R27 22K
R28 12.1K 1% 1/8W
R29 12.1K 1% 1/8W
R30 12.1K 1% 1/8W
R31 5.11K 1% 1/8W
R32 12.1K 1% 1/8W
R33 5.11K 1% 1/8W
R34 12.1K 1% 1/8W
R35 15K 2%
R36 15K 2%
R37 1K 10% 3/4W
R38 12.1K 1% 1/8W
C8 0.1 1% 50V DC
C9 0.1 1% 50V DC
C10 0.1 1% 50V DC
C11 0.1 1% 50V DC
C12 0.15 1% 50V DC
C13 1
C14 1
C15 100PF 5% 500V DC
C16 100PF 5% 500V DC
U4A 1/2 MC1558GH2
U2B 1/2 MC1558GH2
U2A 1/2 MC1558GH2
U3A 1/2 MC1558GH2
U3B 1/2MC1558GH2
R37 COURSE / PATH DDM OFFSET
PART OF P1
9
+ MOD OUT



R29
12.1K
1%
1/8W
TP5
+8V
Q-SW-2
U7C
1/4 CD4016AD3
CR4
JAN1N4148
R52
12K
R50
100K
OUT CONT
IN
R51
100K
-4V
-8V
MC1558GH2
Q-DET-1
U6A
1/4 CD4016AD3
Q INV-2
Q-FL-3
C17
100PF
5%
500V DC
R39
12.1K
1%
1/8W
R40
1 MEGO
R44
31.6K
R46
18K
2%
C18
1
R45
51.1K
1%
1/8W
C19
1
1/2 MC
R38
12.1K
1%
1/8W
U6D
1/4 CD4016AD3
TP6
U3B
1/2MC1558GH2
R41
1 MEGO
TP7
U6C
1/4 CD4016AD3
R42
1 MEGO
U6B
1/4 CD4016AD3
Q-FL-4
R49
1K
2%
R47
31.6K
1%
1/8W
R43
1 MEGO
C20
1
R48
51.1K
1%
1/8W
C21
1
+8V
MOD OUT
- MOD OUT
SAMPLING GATE
CONTROL (+90HZ) IN
SAMPLING GATE
CONTROL (+150HZ) IN



NOTES

1. UNLESS OTHERWISE SPECIFIED
   A. RESISTANCE VALUES ARE IN OHMS, 1/4W, AND ± 5%
   B. CAPACITANCE VALUES ARE IN MICROFARADS, 100V DC, AND ± 10%
2. PREFIX REFERENCE DESIGNATORS WITH LOC 3A1/3A2 OR GS 3A1/3A2/3A3
3. I.C. PIN CONNECTIONS NOT SHOWN

I.C.	$V+/V_{DD}$ (+8V)	V- (-8V)	V_{SS} (-4V)
U1, U2 U3, U4, U5	8	4	
U6, U7	14		7
U8	11	7	

4. REMOVE JUMPER BETWEEN E1 AND E2 FOR TEST
5. GUARD PINS 3 AND 6 OF U8 ARE NOT SHOWN. THEY ARE BOTH CONNECTED TO GROUND

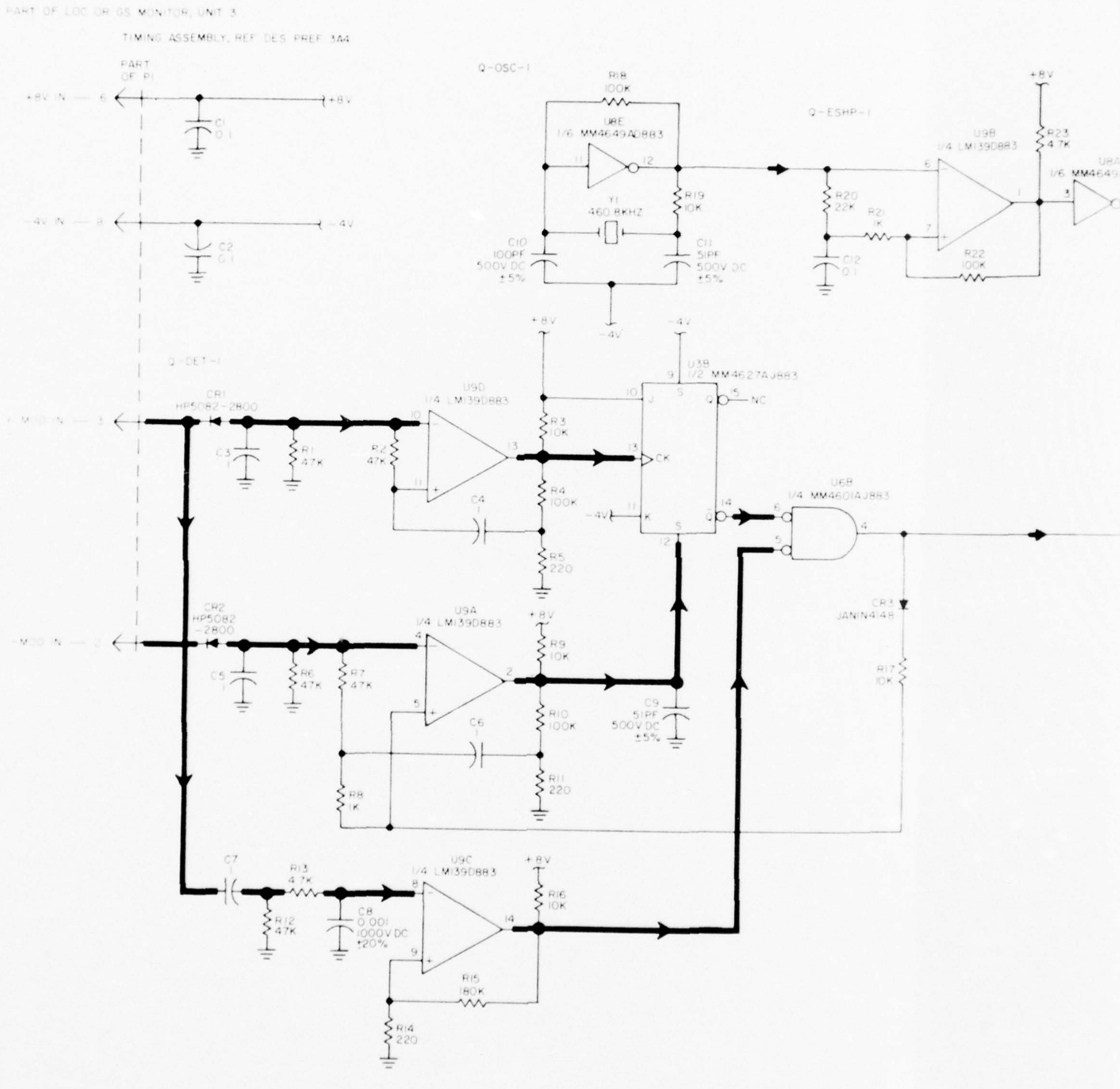
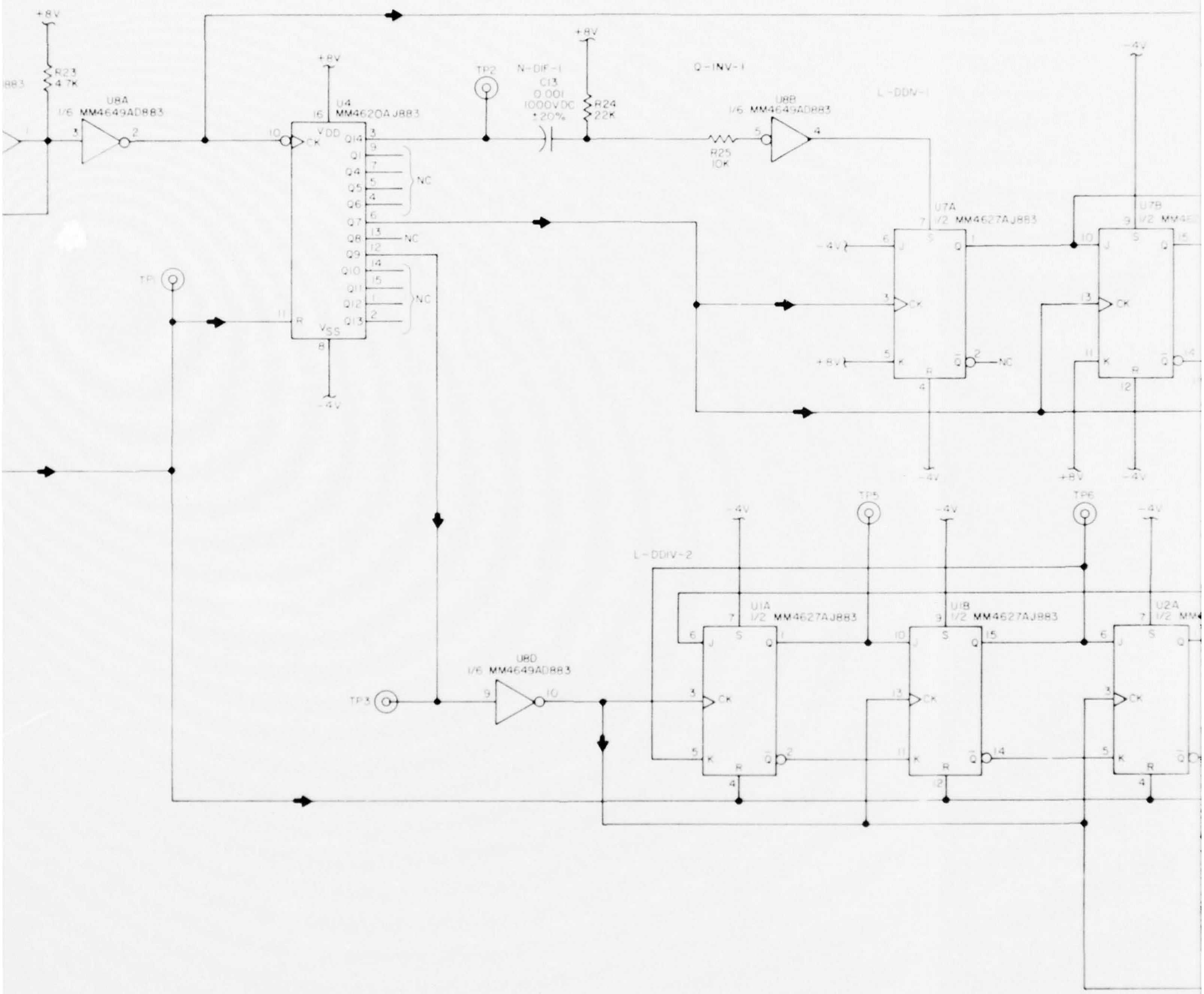
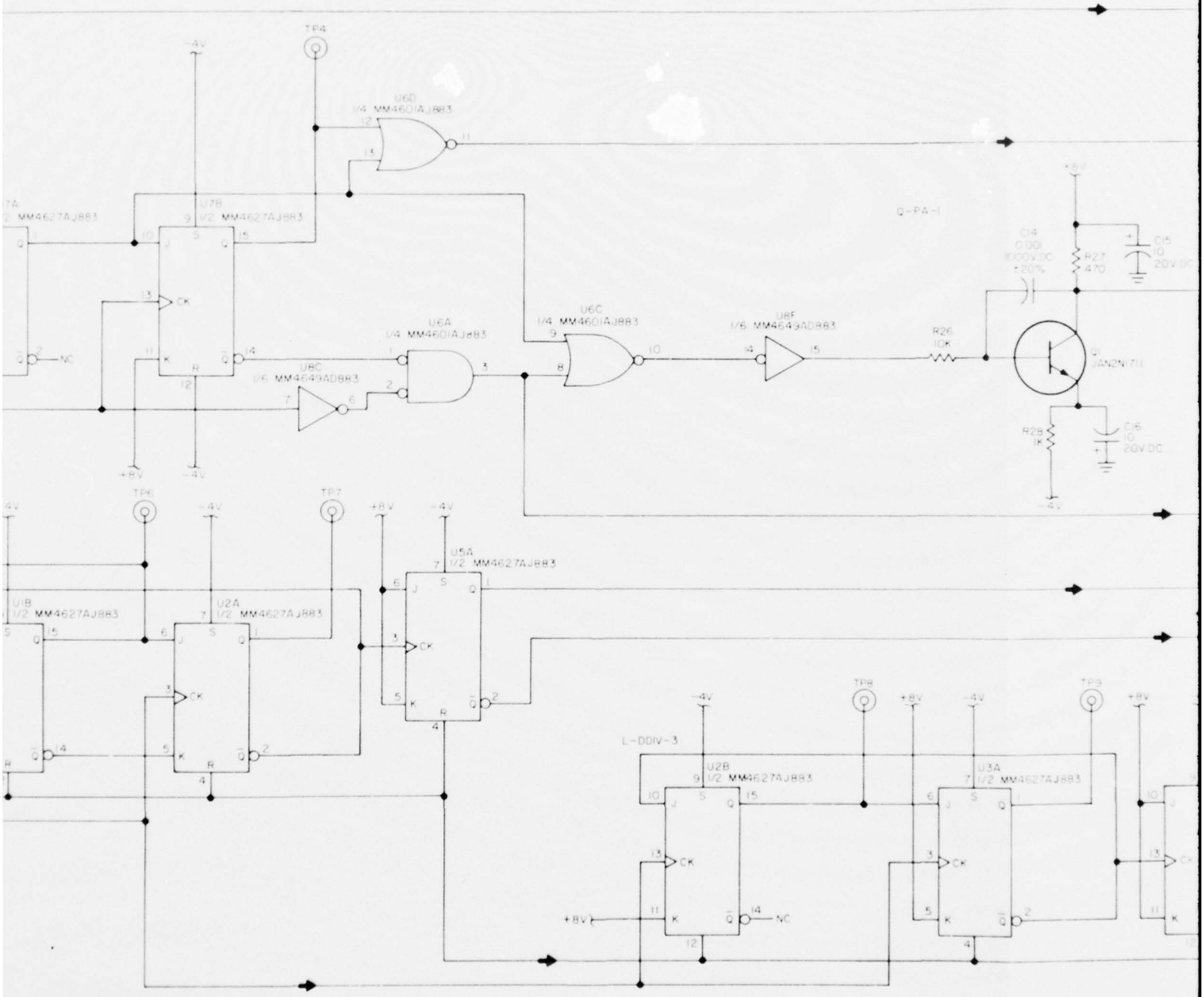


Figure 3.4-5 Timing Assembly, Blocked Schematic



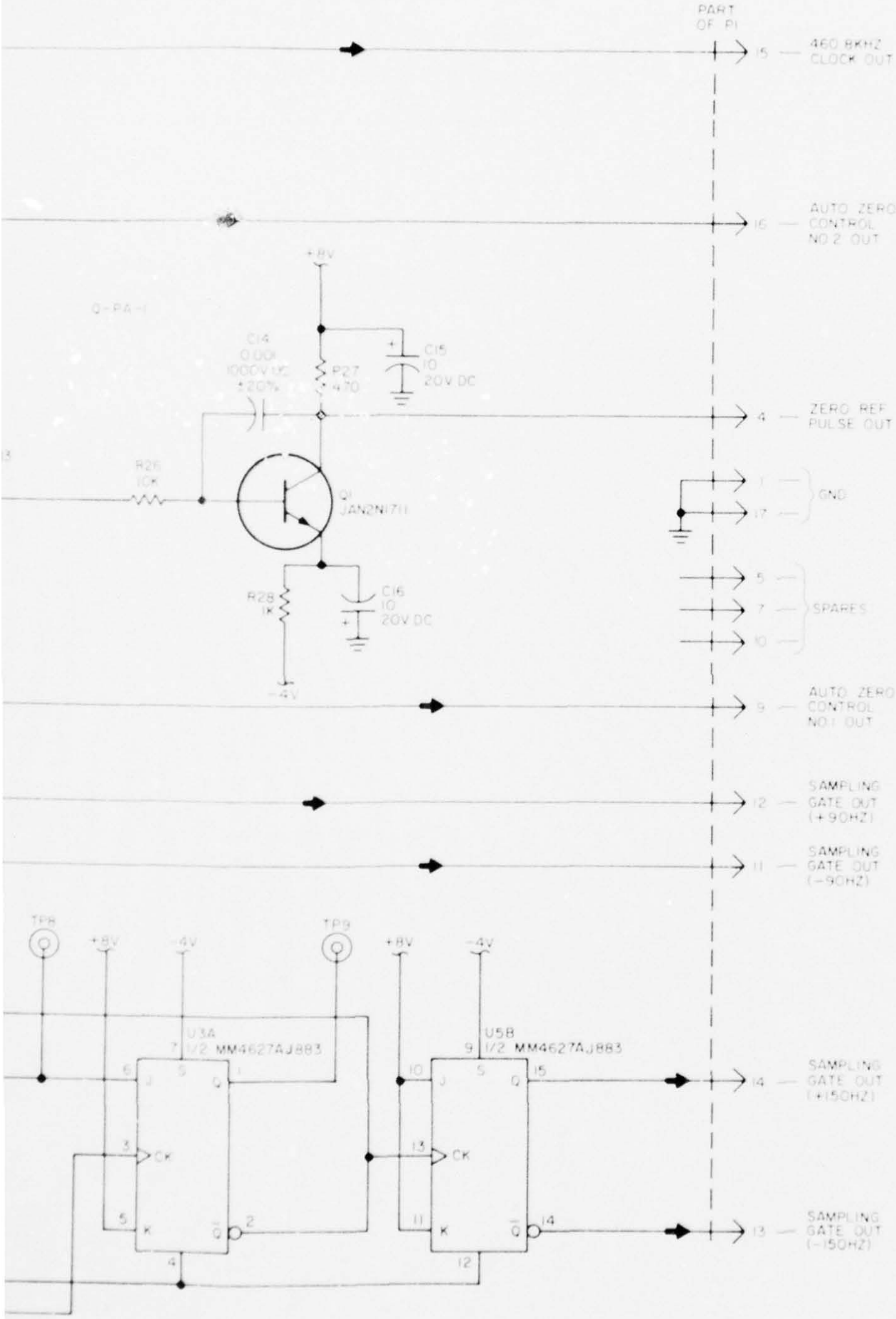
+8V
R23
4.7K
U8A
1/6 MM4649AD883
U4
MM4620AJ883
VDD
VSS
CK
R
Q14
Q1
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
NC
-4V
TP1
TP2
N-DIF-1
C13
0.001
1000VDC
±20%
R24
22K
Q-INV-1
U8B
1/6 MM4649AD883
R25
10K
L-DDIV-1
U7A
1/2 MM4627AJ883
U7B
TP3
U8D
1/6 MM4649AD883
L-DDIV-2
TP5
TP6
U1A
1/2 MM4627AJ883
U1B
1/2 MM4627AJ883
U2A

2



TP4
U6D
1/4 MM4601AJ883
U7B
1/2 MM4627AJ883
Q-PA-1
C14
0.001
1000V DC
±20%
R27
470
C15
10
20V DC
U6A
1/4 MM4601AJ883
U6C
1/4 MM4601AJ883
U8F
1/6 MM4649AD883
R26
10K
Q1
JAN2N1711
U8C
1/6 MM4649AD883
R28
1K
C16
10
20V DC
TP6
TP7
U5A
1/2 MM4627AJ883
U1B
1/2 MM4627AJ883
U2A
1/2 MM4627AJ883
TP8
TP9
L-DDIV-3
U2B
1/2 MM4627AJ883
U3A
1/2 MM4627AJ883
NC
+8V
-4V

3

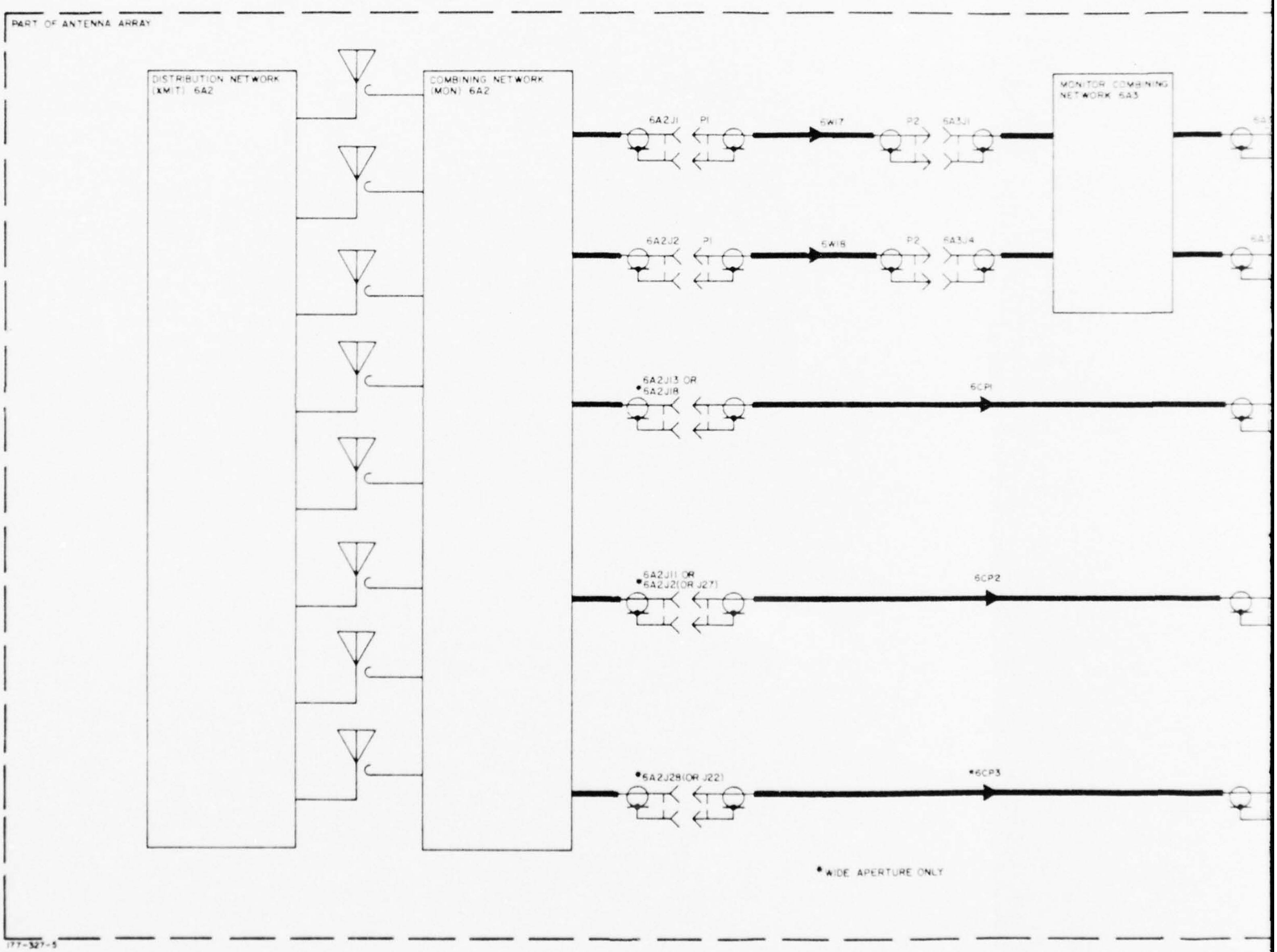


NOTES

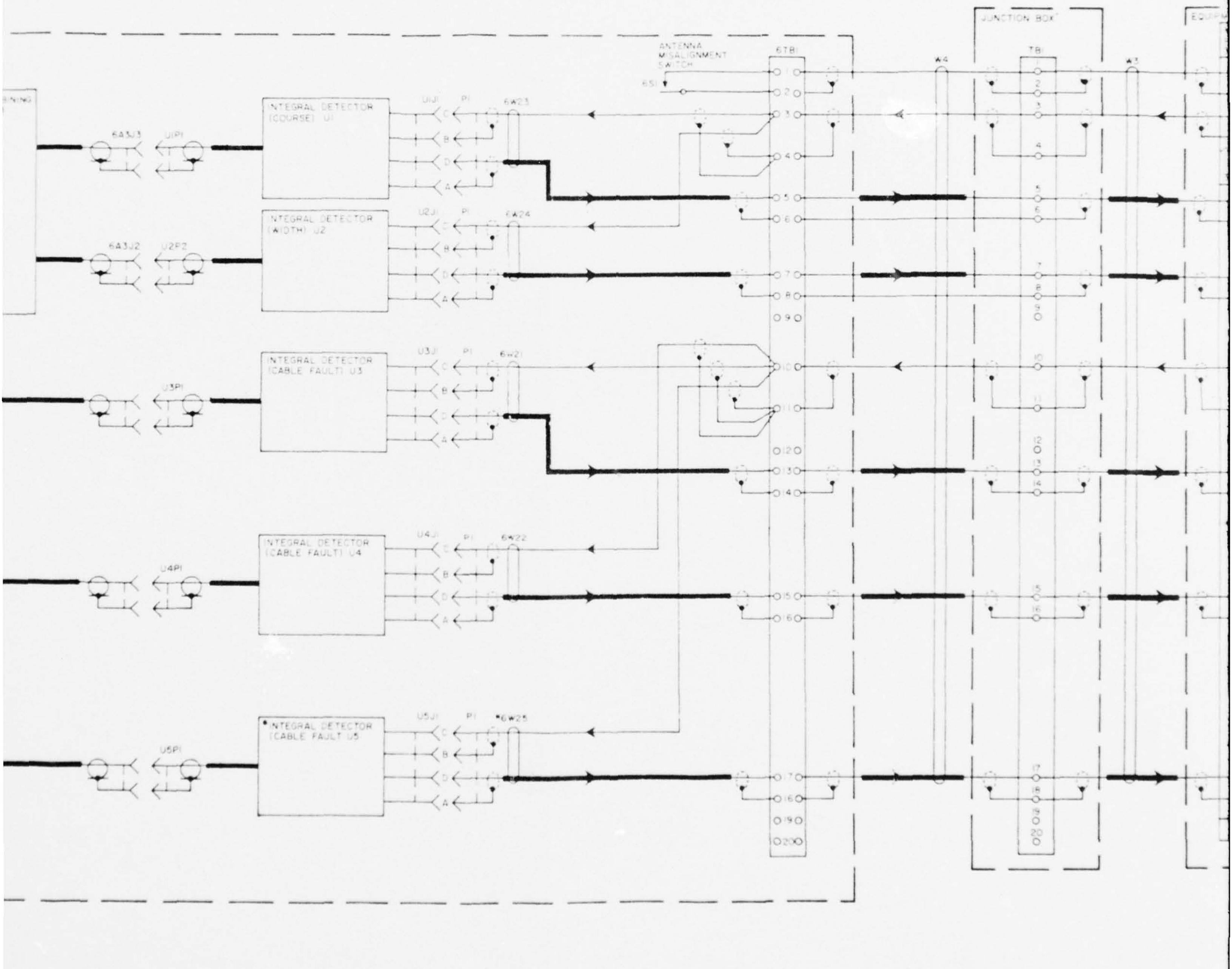
1. UNLESS OTHERWISE SPECIFIED:
   - A. RESISTANCE VALUES ARE IN OHMS, 1/4W, AND ±5%.
   - B. CAPACITANCE VALUES ARE IN MICROFARADS, ±10%, AND 100V DC.
2. EXCEPT FOR U4 V_{DD} AND V_{SS} CONNECTIONS TO THE INTEGRATED CIRCUITS ARE NOT SHOWN. THEY ARE:

IC	V_{DD} (+8V) PIN	V_{SS} (-4V) PIN
U6	14	7
U1, U2, U3, U5, U7	16	8
U8	[illegible]	8
U9	3	12

4



PART OF ANTENNA ARRAY
DISTRIBUTION NETWORK (XMIT) 6A2
COMBINING NETWORK (MON) 6A2
MONITOR COMBINING NETWORK 6A3
6A2J1
P1
6W17
P2
6A3J1
6A2J2
P1
6W18
P2
6A3J4
6A2J13 OR
*6A2J18
6CP1
6A2J11 OR
*6A2J2(OR J27)
6CP2
*6A2J28(OR J22)
*6CP3
*WIDE APERTURE ONLY
177-327-5



JUNCTION BOX
ANTENNA MISALIGNMENT SWITCH
6S1
6TB1
TB1
W4
W3
INTEGRAL DETECTOR (COURSE) U1
INTEGRAL DETECTOR (WIDTH) U2
INTEGRAL DETECTOR (CABLE FAULT) U3
INTEGRAL DETECTOR (CABLE FAULT) U4
INTEGRAL DETECTOR (CABLE FAULT) U5
6A3J3
U1P1
6A3J2
U2P2
U3P1
U4P1
U5P1
U1J1
U2J1
U3J1
U4J1
U5J1
P1
6W23
6W24
6W21
6W22
6W25

2

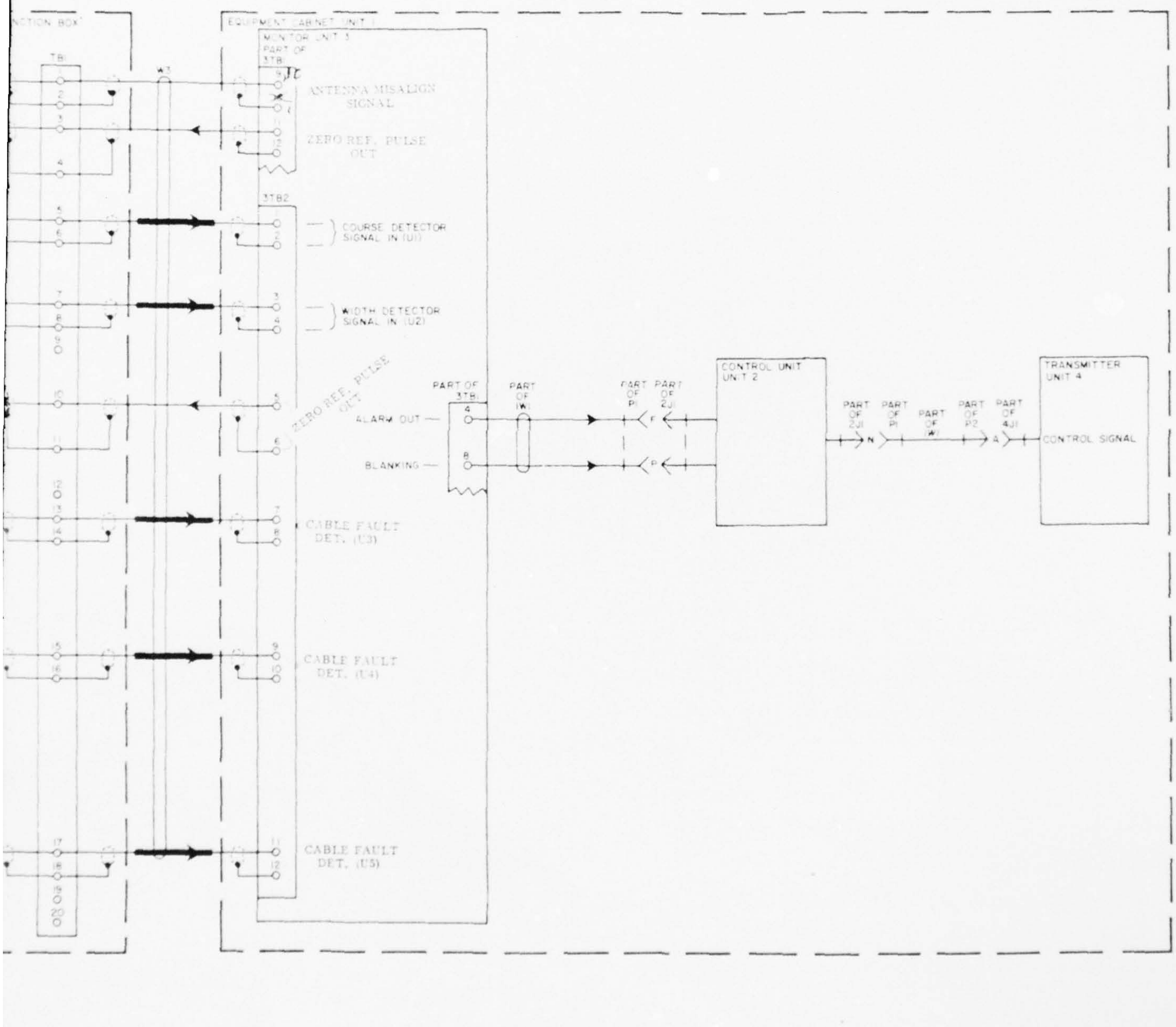


Figure 3.4-6 Monitoring and Control Circuits Diagram

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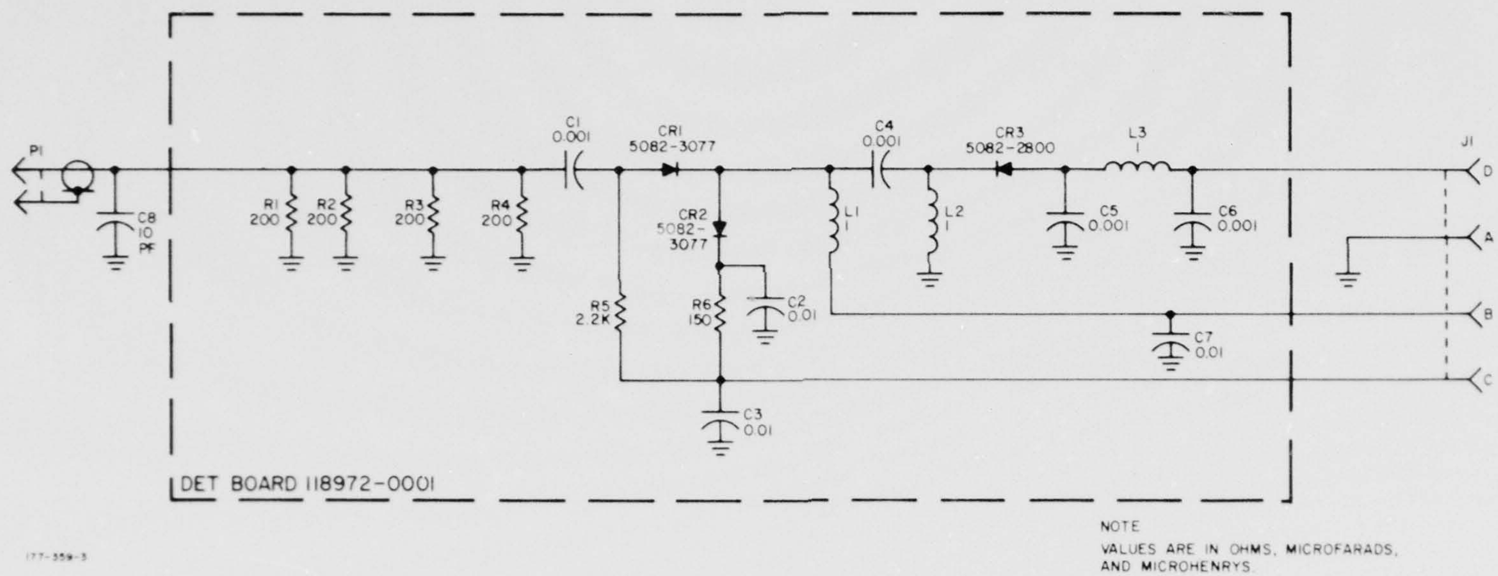


Figure 3.4-7

(Figure 2-5.) Integral Detector, Schematic Diagram

2-13/2-14

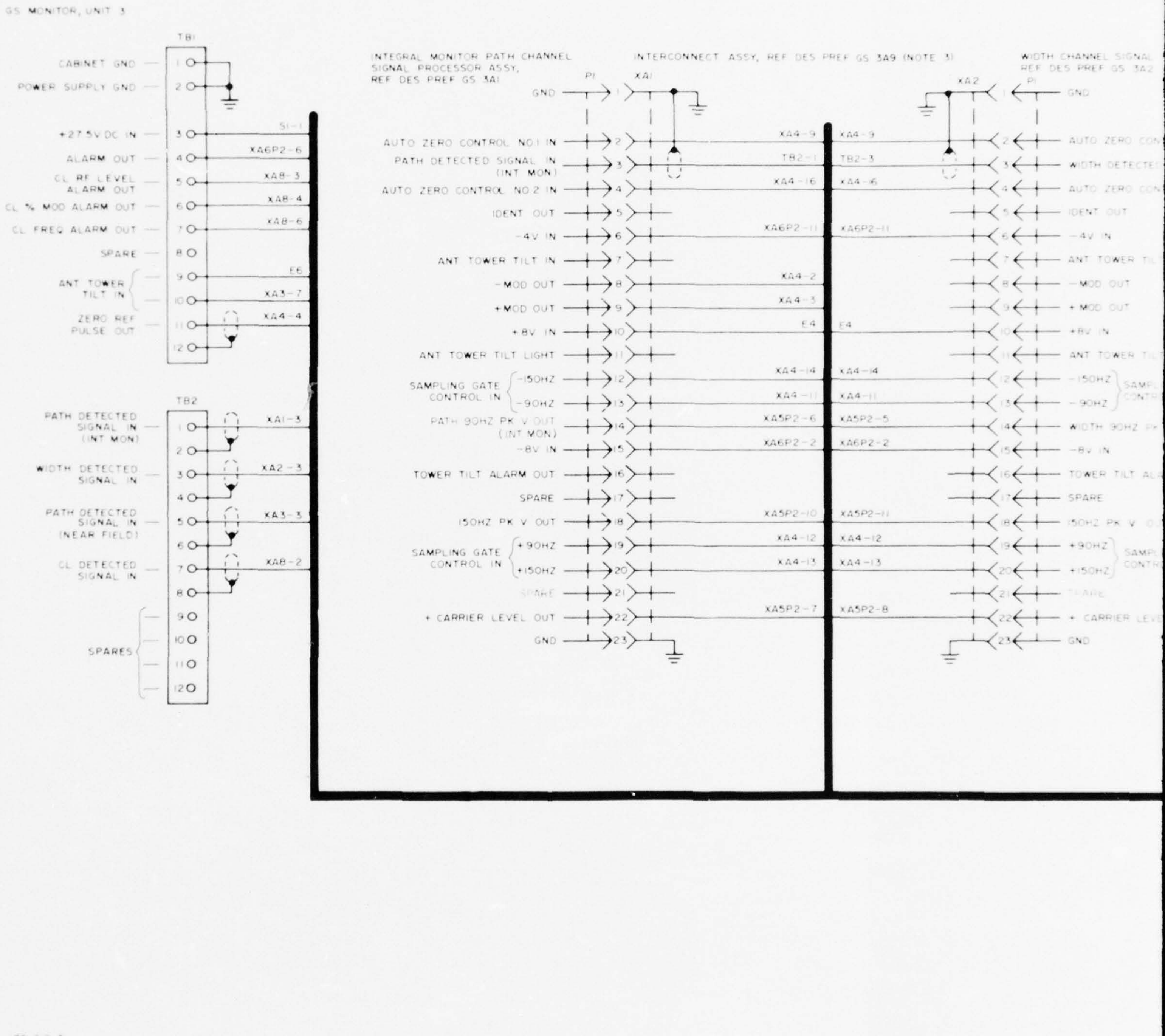
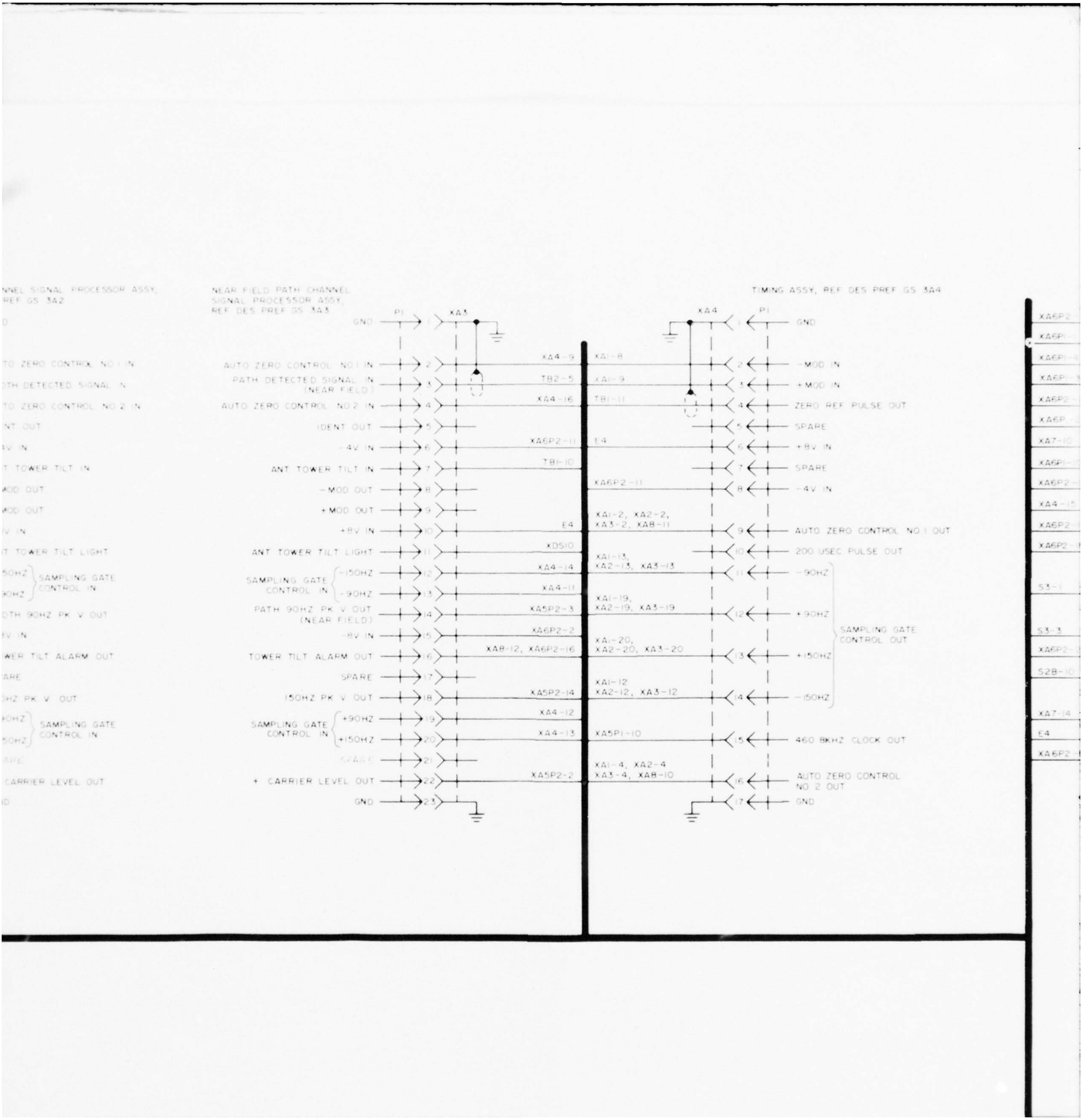
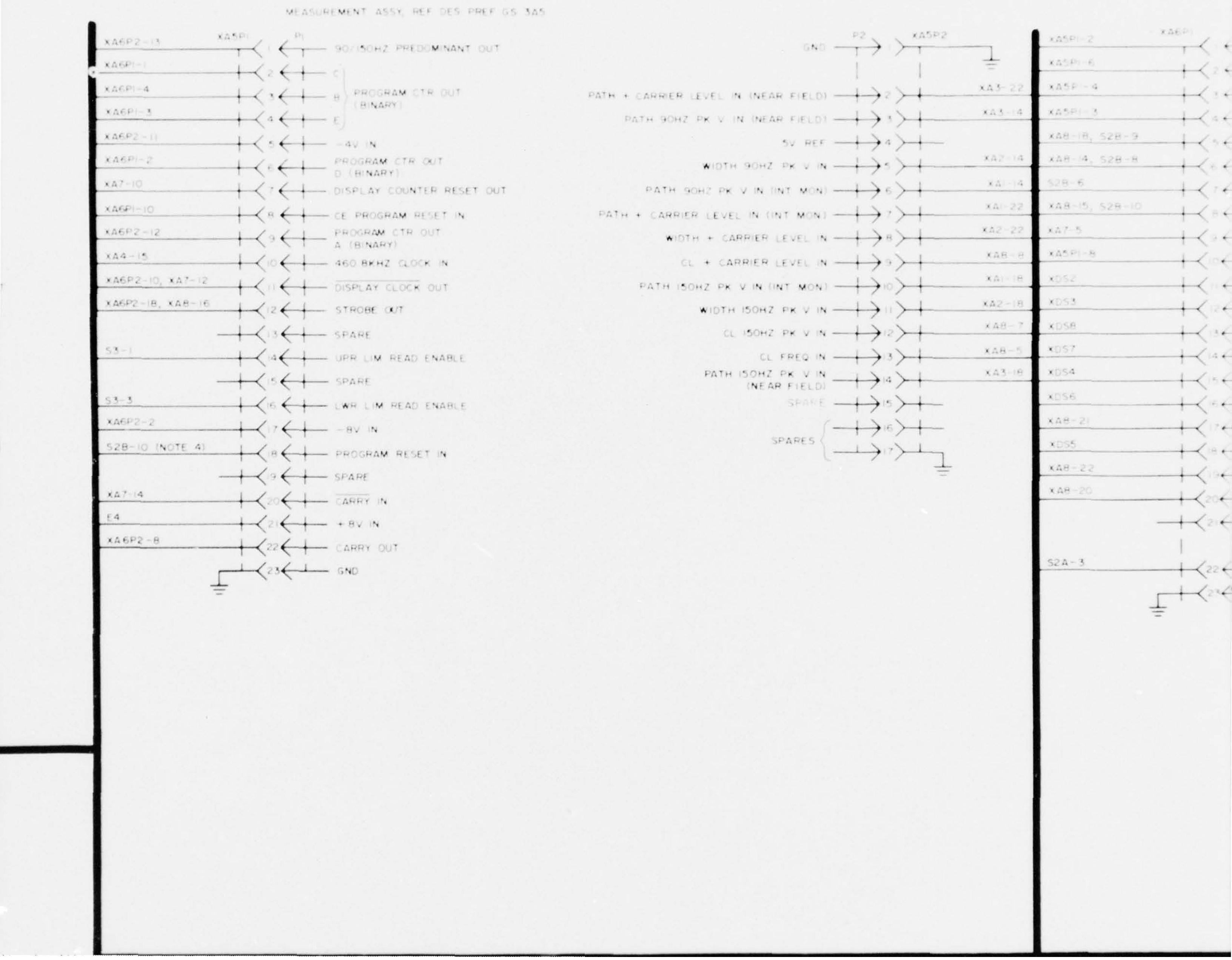


Figure 3.4-8 Glide Slope Monitor Chassis, Blocked Schematic

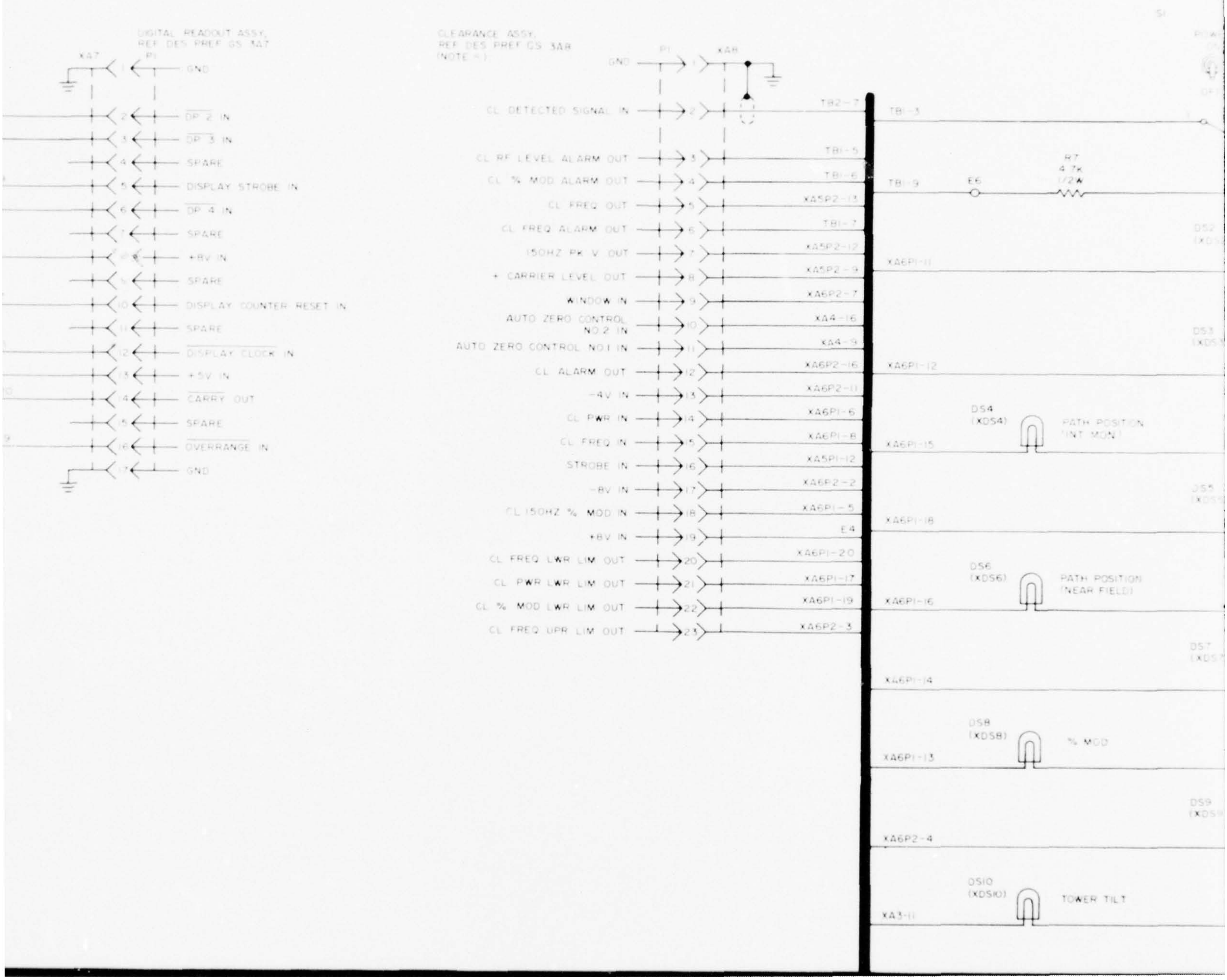


NEAR FIELD PATH CHANNEL SIGNAL PROCESSOR ASSY, REF DES PREF GS 3A3
TIMING ASSY, REF DES PREF GS 3A4
P1
XA3
XA4
GND
AUTO ZERO CONTROL NO 1 IN
PATH DETECTED SIGNAL IN (NEAR FIELD)
AUTO ZERO CONTROL NO 2 IN
IDENT OUT
-4V IN
ANT TOWER TILT IN
-MOD OUT
+MOD OUT
+8V IN
ANT TOWER TILT LIGHT
SAMPLING GATE CONTROL IN
-150HZ
-90HZ
PATH 90HZ PK V OUT (NEAR FIELD)
-8V IN
TOWER TILT ALARM OUT
SPARE
150HZ PK V OUT
+90HZ
+150HZ
+ CARRIER LEVEL OUT
XA4-9
TB2-5
XA4-16
XA6P2-11
TB1-10
E4
XDS10
XA4-14
XA4-11
XA5P2-3
XA6P2-2
XA8-12, XA6P2-16
XA5P2-14
XA4-12
XA4-13
XA5P2-2
XA1-8
XA1-9
TB1-11
XA1-2, XA2-2, XA3-2, XA8-11
XA1-13, XA2-13, XA3-13
XA1-19, XA2-19, XA3-19
XA1-20, XA2-20, XA3-20
XA1-12 XA2-12, XA3-12
XA5P1-10
XA1-4, XA2-4 XA3-4, XA8-10
-MOD IN
+MOD IN
ZERO REF PULSE OUT
+8V IN
-4V IN
AUTO ZERO CONTROL NO 1 OUT
200 USEC PULSE OUT
-90HZ
+90HZ
+150HZ
-150HZ
SAMPLING GATE CONTROL OUT
460 8KHZ CLOCK OUT
AUTO ZERO CONTROL NO 2 OUT

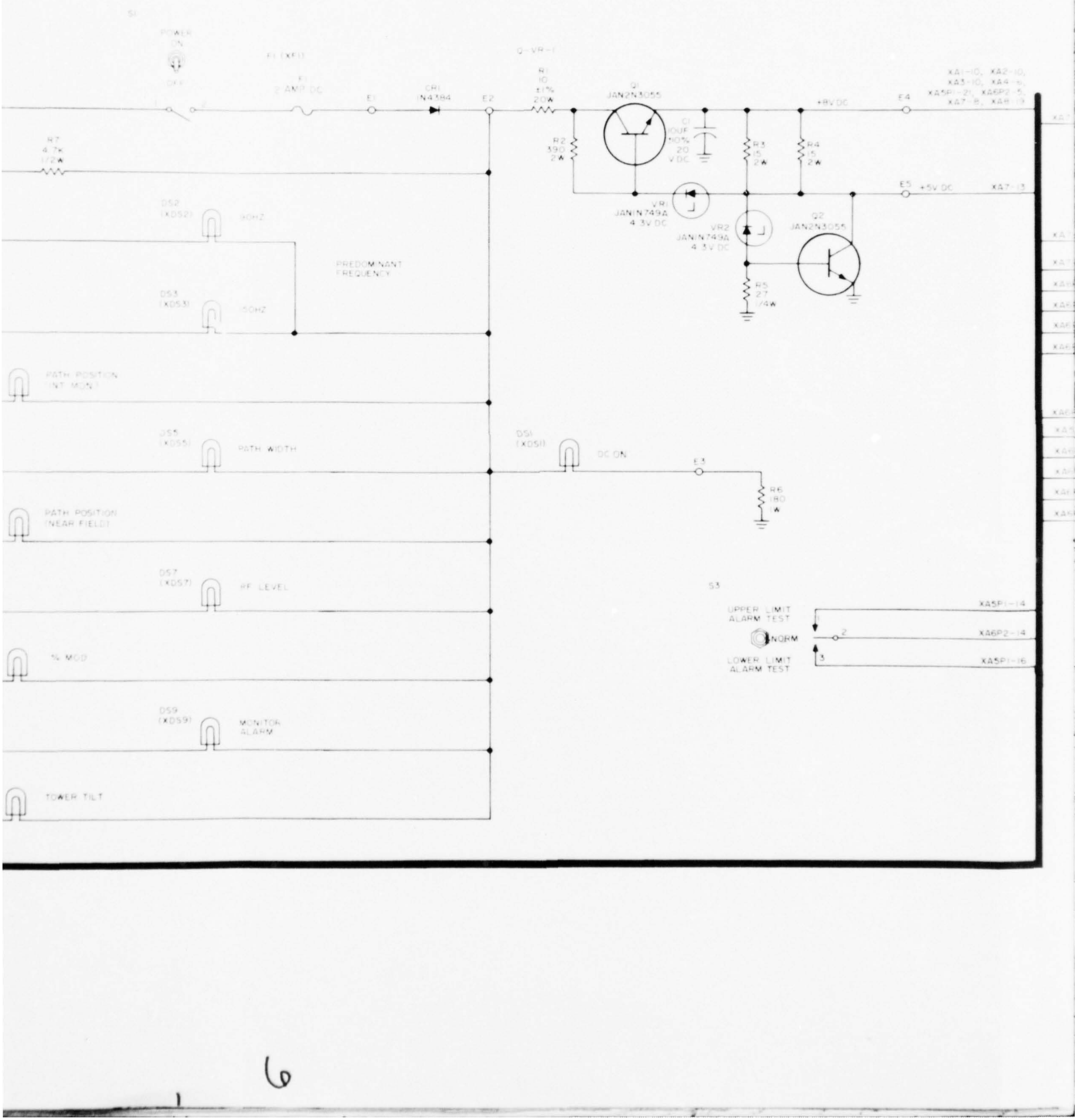


MEASUREMENT ASSY, REF DES PREF GS 3A5
XA5P1
P1
XA6P2-13
XA6P1-1
XA6P1-4
XA6P1-3
XA6P2-11
XA6P1-2
XA7-10
XA6P1-10
XA6P2-12
XA4-15
XA6P2-10, XA7-12
XA6P2-18, XA8-16
S3-1
S3-3
XA6P2-2
S2B-10 (NOTE 4)
XA7-14
E4
XA6P2-8
90/150HZ PREDOMINANT OUT
C
B
E
PROGRAM CTR OUT (BINARY)
-4V IN
PROGRAM CTR OUT D (BINARY)
DISPLAY COUNTER RESET OUT
CE PROGRAM RESET IN
PROGRAM CTR OUT A (BINARY)
460.8KHZ CLOCK IN
DISPLAY CLOCK OUT
STROBE OUT
SPARE
UPR LIM READ ENABLE
SPARE
LWR LIM READ ENABLE
-8V IN
PROGRAM RESET IN
SPARE
CARRY IN
+8V IN
CARRY OUT
GND
P2
XA5P2
GND
PATH + CARRIER LEVEL IN (NEAR FIELD)
PATH 90HZ PK V IN (NEAR FIELD)
5V REF
WIDTH 90HZ PK V IN
PATH 90HZ PK V IN (INT MON)
PATH + CARRIER LEVEL IN (INT MON)
WIDTH + CARRIER LEVEL IN
CL + CARRIER LEVEL IN
PATH 150HZ PK V IN (INT MON)
WIDTH 150HZ PK V IN
CL 150HZ PK V IN
CL FREQ IN
PATH 150HZ PK V IN (NEAR FIELD)
SPARE
SPARES
XA3-22
XA3-14
XA2-14
XA1-14
XA1-22
XA2-22
XA8-8
XA1-18
XA2-18
XA8-7
XA8-5
XA3-18
XA6P1
XA5P1-2
XA5P1-6
XA5P1-4
XA5P1-3
XA8-18, S2B-9
XA8-14, S2B-8
S2B-6
XA8-15, S2B-10
XA7-5
XA5P1-8
XDS2
XDS3
XDS8
XDS7
XDS4
XDS6
XA8-21
XDS5
XA8-22
XA8-20
S2A-3

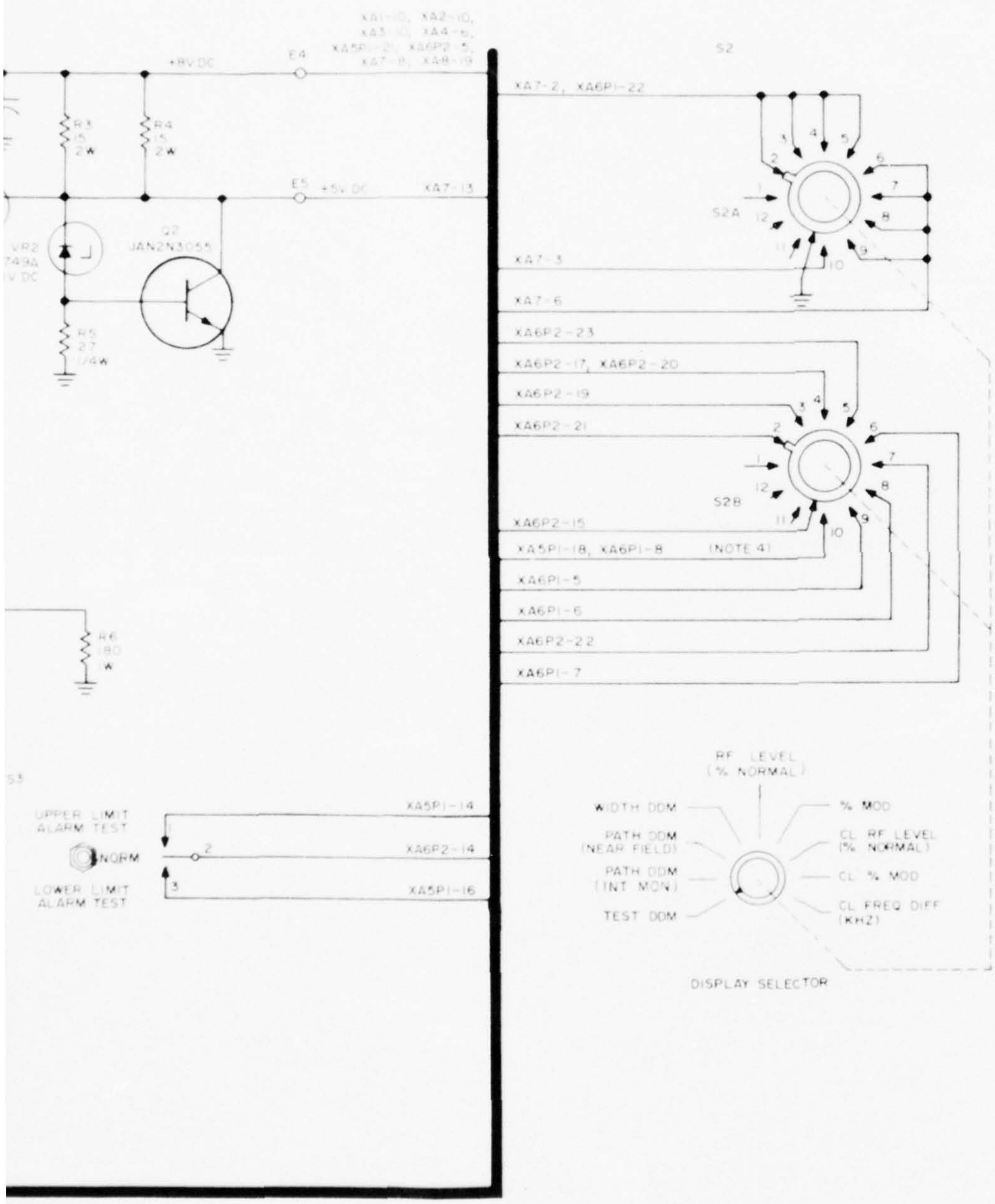
ALARM ASSY, REF DES PREF GS 3A6
XA6P1
P1
PROGRAM CTR OUTPUTS B-E IN
CE 150HZ % MOD OUT
CL PWR OUT
RF LEVEL OUT
CL FREQ OUT
CE PROGRAM RESET OUT
90HZ LAMP OUT
150HZ LAMP OUT
% MOD LAMP OUT
RF LEVEL LAMP OUT
PATH LAMP OUT
NEAR FIELD PATH LAMP OUT
CL PWR LWR LIM IN
WIDTH LAMP OUT
CL % MOD LWR LIM IN
CL FREQ LWR LIM IN
DP 2 IN
GND
P2
XA6P2
GND
-8V OUT
CL FREQ UPR LIM IN
MONITOR ALARM LAMP OUT
+8V IN
ALARM OUT
WINDOW OUT
CARRY IN
OVERRANGE OUT
DISPLAY CLOCK IN
-4V OUT
PROGRAM CTR OUTPUT A IN
90/150HZ PREDOMINANT IN
ALARM LIM OUT
DISPLAY FUNCTION IN
TOWER TILT ALARM IN
CE ALARM IN
NEAR FIELD PATH DDM OUT
STROBE IN
GS PATH OUT
GS LWR LIM SELECT IN
TEST DDM OUT
% MOD OUT
WIDTH DDM OUT
XA1-15, XA2-15, XA3-15, XA5P1-17, XA8-17
XA8-23
XDS9
E4
TB1-4
XA8-9
XA5P1-22
XA7-16
XA5P1-11
XA1-6, XA2-6, XA3-6, XA4-8, XA5P1-5, XA8-13
XA5P1-9
S3-2
S2B-COM
XA3-16, XA8-12
S2B-4
XA5P1-12
S2B-3
S2B-2
S2B-7
S2B-5
S2A-2
S2A-10
XA6P1-9
S2A-6
E4
XA5P1-7
XA5P1-11
E5
XA5P1-20
XA6P2-9
VR3
1N5908
DIGITAL READOUT ASSY
XA7
P1
GND
DP 2 IN
DP 3 IN
SPARE
DP 4 IN
+8V IN
+5V IN
CARRY OUT
OVERRANGE
GND



DIGITAL READOUT ASSY, REF DES PREF GS 3A7
XA7
P1
GND
DP 2 IN
DP 3 IN
SPARE
DISPLAY STROBE IN
DP 4 IN
SPARE
+8V IN
SPARE
DISPLAY COUNTER RESET IN
SPARE
DISPLAY CLOCK IN
+5V IN
CARRY OUT
SPARE
OVERRANGE IN
GND
CLEARANCE ASSY, REF DES PREF GS 3A8 (NOTE 4)
P1
XA8
GND
CL DETECTED SIGNAL IN
CL RF LEVEL ALARM OUT
CL % MOD ALARM OUT
CL FREQ OUT
CL FREQ ALARM OUT
150HZ PK V OUT
+ CARRIER LEVEL OUT
WINDOW IN
AUTO ZERO CONTROL NO.2 IN
AUTO ZERO CONTROL NO.1 IN
CL ALARM OUT
-4V IN
CL PWR IN
CL FREQ IN
STROBE IN
-8V IN
CL 150HZ % MOD IN
+8V IN
CL FREQ LWR LIM OUT
CL PWR LWR LIM OUT
CL % MOD LWR LIM OUT
CL FREQ UPR LIM OUT
TB2-7
TB1-5
TB1-6
XA5P2-13
TB1-7
XA5P2-12
XA5P2-9
XA6P2-7
XA4-16
XA4-9
XA6P2-16
XA6P2-11
XA6P1-6
XA6P1-8
XA5P1-12
XA6P2-2
XA6P1-5
E4
XA6P1-20
XA6P1-17
XA6P1-19
XA6P2-3
TB1-3
TB1-9
E6
R7
4.7K
1/2W
XA6P1-11
XA6P1-12
DS4
(XDS4)
PATH POSITION (INT MON)
XA6P1-15
XA6P1-18
DS6
(XDS6)
PATH POSITION (NEAR FIELD)
XA6P1-16
XA6P1-14
DS8
(XDS8)
% MOD
XA6P1-13
XA6P2-4
DS10
(XDS10)
TOWER TILT
XA3-11
S1



S1
POWER ON
OFF
F1 (XF1)
F1
2 AMP DC
E1
CR1
1N4384
E2
Q-VR-1
R1
10
±1%
20W
Q1
JAN2N3055
C1
10UF
10%
20
VDC
+8V DC
E4
XA1-10, XA2-10,
XA3-10, XA4-6,
XA5P1-21, XA6P2-5,
XA7-8, XA8-19
R7
4.7K
1/2W
R2
390
2W
R3
15
2W
R4
15
2W
E5
+5V DC
XA7-13
VR1
JAN1N749A
4.3V DC
VR2
JAN1N749A
4.3V DC
Q2
JAN2N3055
R5
27
1/4W
DS2
(XDS2)
90HZ
PREDOMINANT
FREQUENCY
DS3
(XDS3)
150HZ
PATH POSITION
(INT MON)
DS5
(XDS5)
PATH WIDTH
DS1
(XDS1)
DC ON
E3
R6
180
1W
PATH POSITION
(NEAR FIELD)
DS7
(XDS7)
RF LEVEL
S3
UPPER LIMIT
ALARM TEST
NORM
LOWER LIMIT
ALARM TEST
XA5P1-14
XA6P2-14
XA5P1-16
% MOD
DS9
(XDS9)
MONITOR
ALARM
TOWER TILT
6



NOTES

1. UNLESS OTHERWISE SPECIFIED
   A. RESISTANCE VALUES ARE IN OHMS, ±5%
2. PREFIX ALL CHASSIS REFERENCE DESIGNATORS WITH GS 3.
3. FOR BETTER READIBILITY, PREFIX A9 HAS BEEN OMITTED FROM ALL ADDRESSES TO CONNECTORS ON INTERCONNECT ASSY A9.
4. REMOVE CONNECTION BETWEEN XA5P1-18 AND S2B-10 FOR CAPTURE EFFECT GLIDE SLOPE STATION MONITORING.
5. CLEARANCE ASSY USED ONLY IN CAPTURE EFFECT GLIDE SLOPE STATIONS. FOR OTHER GLIDE SLOPE STATIONS CLEARANCE ASSY IS REPLACED BY GROUNDING CONNECTOR (WILCOX PART NO. 119357-0001) ON WHICH CONTACTS 21 THRU 23 ARE CONNECTED TO CONTACT NO.1 AND CONTACT 8 IS CONNECTED TO CONTACT 19. THE OTHER CONTACTS ARE NOT USED.

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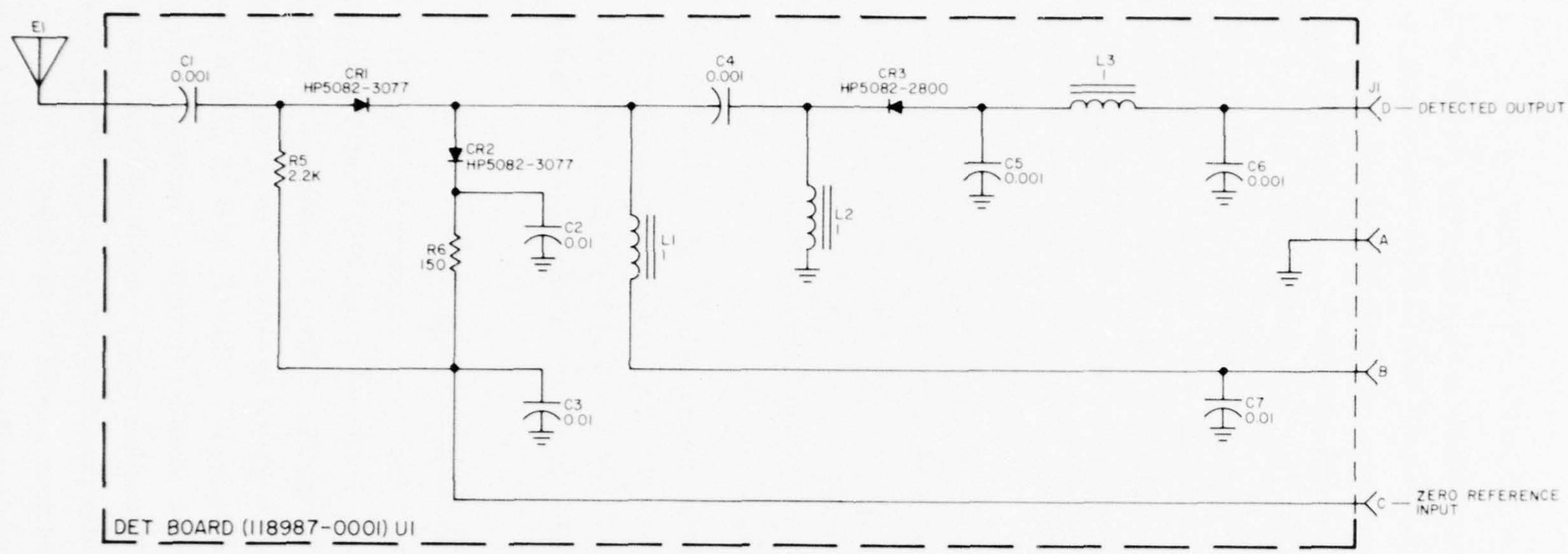

NOTES:
1. VALUES ARE IN OHMS, MICROFARADS, AND MICROHENRYS UNLESS OTHERWISE INDICATED.
2. PREFIX REFERENCE DESIGNATORS WITH GS9.

177-272-3

Figure 3.4-9

(Figure 2-6.) Near-Field Monitor Detector/Antenna, Schematic Diagram

2-15/2-16

3.5 Withstand Capabilities of Vulnerable Components

The surge withstand capabilities of the solid state circuit elements of the Wilcox Mark I/D ILS were determined analytically by calculating the voltages, currents and powers produced in the particular circuit element by a test voltage applied between ground and the terminal connected to a buried control cable conductor. The test waveform used was a 10 x 1000 with a 1000 - volt peak amplitude, i.e. t_r = 10 usec; t_d = 1000 usec, which is the worst case waveform for lightning-induced surges as discussed in Section 2.1. Both positive and negative waveforms were considered. Using the model of surge generators with zero internal impedance, the maximum power to which a semiconductor device may be exposed due to lightning-induced surge can be determined. This value of maximum peak power is compared with the failure level estimates of semiconductor diodes and transistors due to an electromagnetic pulse by Wunsch (11). If the peak surge power exceeds the maximum power that the solid state components can withstand without failure, safe values of voltage and/or current for components in the circuit were then established from the manufacturer's data sheets. In those cases where the available data were not directly applicable, the determination of safe values were based on calculations using data supplied by the manufacturers.

For switches and lamps, a comparison of safe values from manufacturer's data sheet and the worst case test waveforms as mentioned before is usually sufficient to determine whether or not a protective device is required. The details of these and other similar calculations are described in the following several paragraphs.

3.5.1 Withstand Capabilities of Solid State Devices

The withstand level of a solid state semiconductor device is defined as the amplitude of either the voltage or current surge which may be applied to the circuit terminal to just cause failure. Failure of a solid state junction device, such as a transistor or diode, is considered to have occurred if any p-n junction has become an open or a short circuit [11]. This effect of an open or a short circuit can occur due to the application of either forward or reverse voltages, although failure mechanism of the PN junctions may be due to different causes for the two cases. The principal breakdown mechanisms on a single PN junction are:

(1) Surface breakdown around the junction;

(2) Internal breakdown through the junction within the body of the device.

The actual destruct mechanism for surface breakdown is usually the establishment of a high leakage path around the junction thus nullifying junction action. The analysis of surface breakdown is very difficult since it depends on a number of parameters, for example, the geometry of the device, doping profile, lattice imperfection and discontinuities on the surface, some of which are probably not known at the present time. Thus, theoretical models which have been used are generally limited to the consideration of potential gradients at the surface under homogeneous crystal conditions and approximate geometrical boundaries which is then amenable to theoretical calculations. It becomes even more formidable if a transient condition is imposed. Davies and Gentry [12] state, "Unfortunately the transient energy which can be dissipated during surface breakdown is both unpredictable and appreciably lower than that which can be absorbed within the body of the PN junction device." Nonetheless, junctions have now been successfully designed and built which exhibit body breakdown prior to any surface breakdown phenomenon.

In internal breakdown, the destruct mechanism apparently results from changes in the junction parameters due to electrical stress which usually result in locally high temperature within the junction. For very short and large amplitude surges, the effect is localized causing melting at hot spots which results from dislocation and imperfection of the crystal lattice within the junction. For long term heating at temperatures well below the melting level, alloying and impurity diffusion occurs to such an extent that the junction is either totally destroyed or its properties drastically changed.

While both failure mechanisms are caused by negative surges only the internal body breakdown mechanism is responsive to positive surges since the potential gradients on the surface across the junction are normally quite small when the junction is conducting. Furthermore, it was found experimentally that in general a PN junction is more vulnerable to power dissipation in the reverse polarity mode and the base-emitter junction is more vulnerable than the other junction in a transistor.

While long term heating that degrades the performance of a solid state device is very important in the studies of semiconductor vulnerability, it is believed that the short and large amplitude surges which can cause hot spots are the most probable failure cause of semiconductors in lightning. Although the hot

spot may be due to one of the many different microscopic mechanisms, it has been found that most of these failure mechanisms are linked primarily to the junction temperature. Therefore, the theoretical treatment of the problem can be reduced to a thermal analysis. For pulse time between 0.1 to 20 microseconds the junction failure condition can be expressed as:

$$P \quad \sqrt{t} \quad = \quad K \tag{1}$$

where t is the duration time in seconds and P is the magnitude of rectangular pulse power in watts and K is a constant which depends on the particular solid state device in units of watt-seconds$^{1/2}$.

The value of K can be calculated from either the manufacturer's data sheet or reference [11]. Thus, for a given value of K, the maximum transient power a particular solid state device can withstand for a given pulse can be determined very easily from Equation (1).

<u>3.5.1.1 Withstand Capabilities of Transistors JAN 2N3055 and JAN 2N1711</u>

The JAN 2N3055 is an NPN Silicon high power transistor used as a voltage regulator in the Monitor mainframe +8 VDC and +5V supplies (see Figure 3.4-1). The value of K is not available from reference [11] for this transistor and was calculated using the value of thermal resistance from junction to case, Θ_{jc} = $1.5^{o}C$/watts [13, p. 200-line 55], and the formula [11, Equation III-8]:

$$K = 31.5\,\Theta_{jc}^{-(1.11)} = 31.5(1.5)^{-(1.11)} = 20.1.$$

This value of K must be modified since the pulse is triangular and exponential, from the value above to $K' = (3/\sqrt{2})K$ as derived by Huddleston, et. al. [6]. Thus $K' = 42.6$ and the withstand level of the JAN 2N3055 is

$$P = K't^{-1/2} = (42.6)(1,000 \times 10^{-6}\,\text{sec})^{-1/2} = 1,350 \text{ watts peak power.}$$

The JAN 2N1711 transistor is an NPN silicon transistor used in switching applications and as an amplifier in both the Localizer and Glide Slope Stations. The withstand level can be calculated by first calculating the thermal resistance from junction to ambient, Θ_{ja}. This was calculated in two ways: (1) using the derating factor in free air at $25^{o}C$, $\Theta_{ja} = (4.5\text{mW/oC})^{-1} = 222^{o}C$/Watt and (2) using the maximum operating temperature and maximum dissipation in ambient air $\Theta_{ja} = (175^{o}C - 25^{o}C)/800\text{mW} = 181.5^{o}C$/Watt. Then $K = 972.2\,\Theta_{ja}^{-1.24}$ = 1.54 for Θ_{ja} = $181.5^{o}C$/Watt and K = 1.20 for Θ_{ja} = $222^{o}C$/Watt. [11, Equation

III-10]. Another means of finding K is the junction capacitance model [11, p. 21-24] using the equation:

$$\frac{K_1}{C_j} = (1.1 \times 10^{-3}) V_{bd}^{(0.81)}$$

where C_j = junction capacitance (in pF) and V_{bd} = breakdown voltage of the transistor. BV_{ceo} = 30 volts for the 2N1711, and we will then assume V_{bd} = 40 volts. Using the value of C_j = 25pF [13], then:

$$K_1 = (25 \text{ pF})\ (1.1 \times 10^{-3})\ (40)^{(0.81)} = 0.546$$

Wunsch, et.al [11] lists the value of K = 0.36 without saying which model was used for the calculation. The values of K, K' and P_{max} calculated using the methods listed here are shown in Table 3.5-1.

Table 3.5-1 Withstand Levels of JAN 2N1711

Basis of Calculation	K	K'	P_{peak} (watts)
Θ_{ja} = 181.5°C/watt	1.54	3.27	103.1
Θ_{ja} = 222°C/watt	1.20	2.55	80.5
C_j = 25 pF, V_{bd} = 40 volts	0.546	1.16	36.6
Wunsch, et.al. (11)	0.36	0.76	24.2

The most conservative value, P_{max} = 24.2 watts will be used to determine the vulnerability for the 2N1711.

3.5.1.2 Withstand Levels of Integrated Circuits: MC1558GH2 and CD4016AD3

The integrated circuit MC1558GH2 is a dual operational amplifier with an input impedance of ~200M Ω, and is rated at Maximum Input Offset Current of 0.5 μADC, Maximum Power Supply Voltages of +22 and -22 volts, Maximum Input Differential Voltage equal to the Power Supply Voltage Applied, Power dissipation of 680 mW for the entire circuit, and a derating factor of 6mW/°C. The derivations of withstand levels of Reference [11] do not apply to this circuit. With no further guide lines available, the requirement that the maximum input differential voltage not exceed the applied power supply voltages will be used to determine the protection levels.

The integrated circuit CD4016AD3 is a Quadrature Bilateral Switch with four switches on a single chip. The input impedance is typically 10^{12} ohms, indicating a field effect device, with a maximum control voltage of $\pm$ 15 volts. This type of circuit is also not covered by the derivations of Reference [11] and the criteria for protection levels will be that the voltages applied to the circuit do not exceed the maximum control voltage.

3.5.1.3 Withstand levels of diodes: JAN 1N748A, JAN 1N749A, 1N4148, 1N4384, HP 5082-2800 and HP 5082-3077

The JAN 1N748A diode is a 3.9 volt silicon zener reference diode with a maximum power dissipation of 400mW at 25°C and a maximum ambient temperature of 175°C. [14, p. 154, line 48]. Using these values to calculate Θ_{ja}, K, K' and P:

$$\Theta_{ja} = \frac{175^{\circ}C - 25^{\circ}C}{0.4 \text{ watts}} = 375^{\circ}C/\text{watt}$$

$$K = 972.2(375)^{-1.24} = 0.625$$

$$K' = \frac{3}{\sqrt{2}} K = 1.326$$

$$P_{peak} = K'/\sqrt{t} = 1.326\ (1000 \times 10^{-6})^{-1/2} = 41.9 \text{ watts peak power}$$

From Wunsch, et. al. [11] K = 1.1 and P_{max} = 73.8 watts, for the 1N748A, but since the value of 41.9 watts calculated above is the more conservative value, it shall be used in calculating the protection requirements for the JAN 1N748A diode.

The JAN 1N749A diode is also a silicon reference diode with a reference voltage of 4.3 volts, maximum dissipation of 400mW at 25° and a maximum ambient temperature of 175°C. [14, p. 155, line 35]. Since these are the same values as for the JAN 1N748A, the calculated values for the JAN 1N749A are Θ_{ja} = 375°C/watt, K = 0.625, K' = 1.326 and P_p = 41.9 watts peak power.

The 1N4148 is a silicon highspeed switching diode with a peak inverse voltage of 75 volts and a maximum reverse current of 25nA at 20 volts, 25°C ambient and a maximum temperature of 200°C at the junction. The diode also has a junction capacitance of 4.0 pfd, and an absolute max. forward current of 200mA at 175° maximum ambient temperature. Using the maximum forward current at a forward voltage of ~ 1.0 volts, the maximum power dissipation is 200mW at 175°C ambient maximum.

Then:

$$\Theta_{ja} = \frac{175^o - 25^oC}{200\ mW} = 750^oC/watt$$

$$K = 972.2(750)^{-1.24} = 0.265$$

$$K' = 0.562$$

$$P_p = 17.8\ watts$$

Calculating K from the junction capacitance method gives

$$K = C_j\ (1.1 \times 10^{-3})\ V_{bd}^{\ (0.81)} = (4.0)(1.1 \times 10^{-3})(75)^{0.81} = 0.145$$

$$K' = 0.308$$

$$\underline{P_p = 9.74\ \text{watts peak power}}$$

This lower value will be used to determine the protection necessary.

The 1N4384 is a silicon rectifier with the following specifications: [14, p. 307, line 98.]

Peak Inverse Voltage	400 volts
Max. Surge Current (250)	50 Amps for 1 cycle of 60 Hz
Max. Temperature	175^oC ambient
Max. Forward Voltage Drop	1.3 volts at 1 amp at 100^oC ambient
Max. Average Forward Current	1.0 A at 100^oC ambient
Max. Reverse Current	0.25 mA at 150^oC ambient, 400 volts

The maximum power dissipation at 100^oC is then (1.3 volts)(1.0A) = 1.3 watts.

Then:

$$\Theta_{ja} = \frac{175^oC - 100^oC}{1.3\ watts} = 57.7^oC/watt$$

$$K = 972.2(57.7)^{-1.24} = 6.37$$

$$K' = 13.51$$

$$P_{peak} = (13.51)(1000 \times 10^{-6})^{-1/2} = \underline{427.2\ \text{watts peak power}}$$

The HP5082-2800 (JAN 1N5711) is an epitaxial, planar passivated metal-silicon Schottky barrier high-speed switching diode mounted in the integral detectors of both glide slope and localizer stations. It has a peak inverse voltage of 70 volts, a capacitance of 2.0 pf, a max ambient temperature of 200^oC, an absolute maximum power dissipation of 250 mW at 25^oC, and a derating factor of $1.43mW/^oC$ above 25^oC. [15] The maximum peak power can be calculated using

the thermal resistance Θ_{ja} or using the junction capacitance. From the thermal resistance method: (note: this is a planar device)

$$\Theta_{ja} = [1.43\text{mW}/^{o}\text{C}]^{-1} = 699.3^{o}\text{C/watt}$$

or

$$\Theta_{ja} = \frac{200^{o}-25^{o}\text{C}}{250\text{mW}} = 700^{o}\text{C/watt}$$

$$K = (972.2)(700)^{-1.24} = 0.288$$

$$K' = 0.612$$

$$\underline{P_p = 19.34 \text{ watts}}$$

For the junction capacitance method:

$$K = (2.0)(1.1 \times 10^{-3})(70)^{(0.81)} = 0.0686$$

$$K' = 0.146$$

$$P_p = 4.61 \text{ watts.}$$

The lower rating, $P_p = 4.61$ watts will be chosen to determine the protection requirements.

The HP5082-3077 is a planar-passivated silicon PIN switching diode also used in all of the integral detectors in both glide slope and localizer stations. The ratings on this diode are: Breakdown voltage - 200 volts, junction capacitance 0.3 pf, absolute maximum power dissipation 250mW ($T = 25^{o}C$) and absolute maximum operating temperature, $150^{o}C$. [15] Calculating P_p using the thermal resistance method gives:

$$\Theta_{ja} = \frac{150^{o}-25^{o}\text{C}}{250\text{mW}} = 500^{o}\text{C/watt}$$

$$K = (972.2)(500)^{-1.24} = 0.438$$

$$K' = 0.928$$

$$P_p = 29.4 \text{ watts}$$

calculating P_p by the junction capacitance model gives:

$$K = (0.3)(1.1 \times 10^{-3})(200)^{0.81} = 0.0241$$

$$K' = 0.0511$$

$$P_p = 1.62 \text{ watts}$$

The lower rating of 1.62 watts will be used to determine the protection requirements for the HP5082-3077 diode.

Table 3.5-2 shows the maximum peak power withstand levels for each of the devices in this section and the method used to determine this value.

Table 3.5-2

Withstand levels for Vulnerable Semiconductor Devices in
Wilcox 1/D System

Device	Withstand Level (Peak Power, Watts)	Computation Method Used
JAN 2N1711	24.2	Wunsch, et.al. [11]
JAN 2N3077	1,350	Thermal resistance, junction to case
JAN 1N748A	41.9	Thermal resistance, junction to ambient
JAN 1N749A	41.9	Thermal resistance, junction to ambient
1N4148	9.7	junction capacitance
1N4384	427.2	thermal resistance, junction to ambient
HP 5082-2800 (JAN 1N5711)	4.6	junction capacitance
HP 5082-3077	1.6	junction capacitance

In general, the junction capacitance method gives more conservative values and Wunsch, et.al. [11] refer to this method as the most accurate one in predicting failure levels. However, the data necessary for this calculation was not available for all devices listed above.

3.5.2 Withstand Levels of Other Components in Wilcox 1/D ILS System

In addition to the semiconductor components in the system, certain lamps and switches vital to the operation of the system are also vulnerable to lightning induced surges. These are the indicator lamps, on both glide slope and localizer stations, the Antenna Tower Tilt Switch (GS) and the Antenna Misalignment Switch (Loc.)

The indicator lamps are 28 volt, 0.04 amp, units (1.2 watts max.). The failure level of these lamps is not known, but a conservative estimate based on their poor ability to conduct heat away by the leads, would limit the maximum peak power to a few watts.

The Antenna Misalignment Switch in the Localizer Status is a Honeywell - 1HS41 microswitch rated at 28 VDC, 25 Amp resistive or 120 VAC, 1 amp resistive. Since the switch is normally closed, the primary protection would be to limit the current through the switch under pulse conditions to the 1 Amp level.

The Glide Slope Station Antenna Tilt Switch manufactured by Wilcox has a normal working voltage of 28 VDC with a current capacity of $\sim$ 1A [16]. This switch is normally open so the primary protection would be to prevent the voltage from rising high enough to arc over the switch and secondly, if the switch is closed at the moment of surge, to limit the current to $\sim$ 1 amp.

The electrolytic capacitors, 3A4-C15 and -C16 in the Timing Assembly Card are rated at 10 μF, 20WVDC. To prevent the capacitor from failing under surgeconditions, the voltage across the capacitors should be prevented from rising above the working voltage and should be prevented from reversing polarity.

In Chapter 4, the protection requirements for each of the components discussed in Chapter 3 will be determined taking into account the maximum peak power determined here and the other components in the various circuits which may limit the voltage or current overload reaching a vulnerable component.

CHAPTER 4

RECOMMENDED PROTECTION REQUIREMENTS FOR VULNERABLE COMPONENTS AND INSTALLATION POINTS

4.1 Localizer Station

The protection requirements will be determined terminal by terminal starting with the Localizer Station connections to Cable W4 (see Table 3.4-1). The ends of this cable are at terminal blocks 1TB1 (shelter) and 6TB1 (Antenna Array). Typical installations are shown in Figures 4.1-1 and 4.1-2. Through terminal 1TB1-1, the surge current to 3TB1-9 and thus to several components is limited by R7 (4.7KΩ) to a peak current of $1000/4.7 \times 10^3 = 0.213$ amps. The peak power that the 1N4384 diode must dissipate for a 1000V surge is then (1.3 volts) (0.213 amps) = 0.28 watts, thus the 1N4384 will withstand negative pulses. When the diode is reverse biased (positive induced pulses), and breaks down at its PIV of 400 volts, then the maximum peak power is (400)(0.213 amps) = 85 watts which is less than the withstand level of 427 watts (see Table 3.5-2).

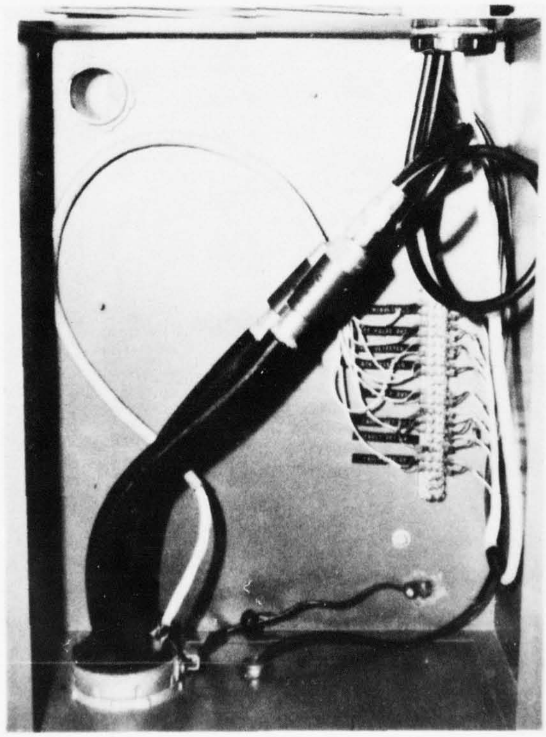

Figure 4.1-1A: Typical installation of terminal block 1TB1 in the Localizer Station

Figure 4.1-1B: Close up View of Terminal Block 1TB1
(Note fix on cable fault detector.)

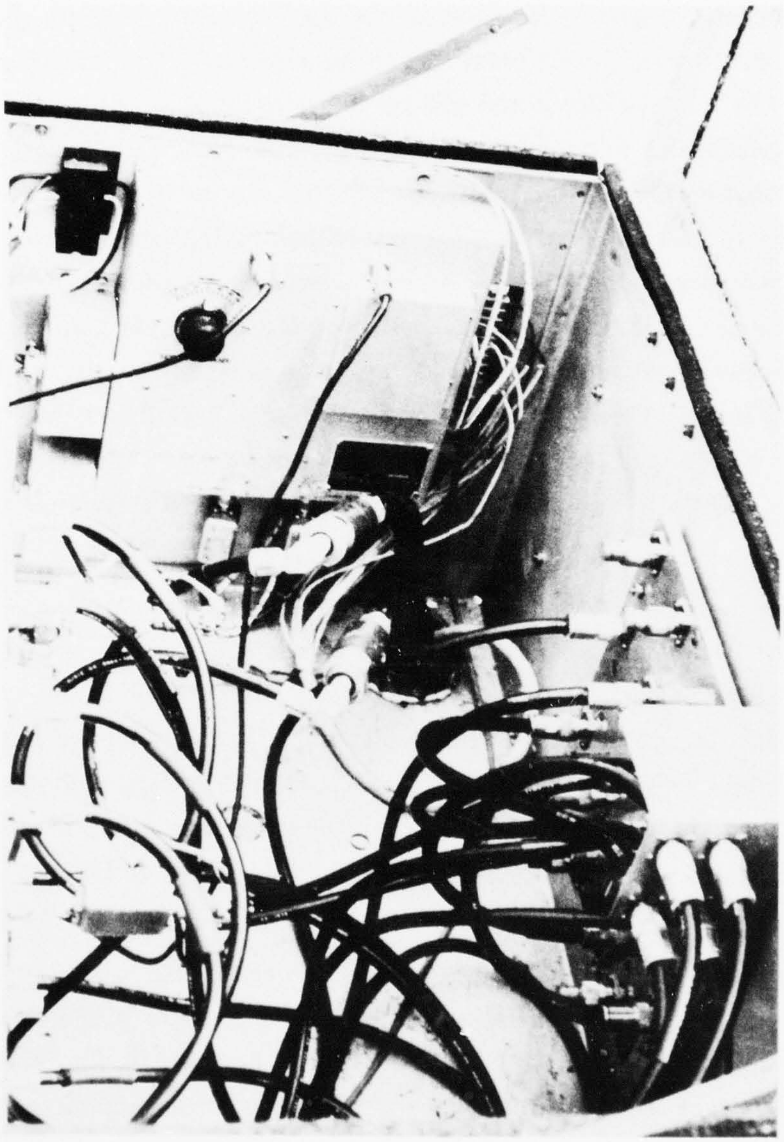

Figure 4.1-2: Typical Installation of Localizer Terminal Block 6TB1 at the Antenna Array.

Q1 of the +8 and +5 Mainframe (JAN 2N3055) is also connected to 1TB1-1, and the current through the collector to emitter is limited by R7 to 0.213 amps maximum peak current. If Q1 is fully saturated at $\sim$ 1.0 volts, then the maximum surge power is $\sim$ 0.213 watts, well below the withstand level. The maximum V_{CB} is determined by R2 (390 ohms) and will be a maximum of $V_{CB\ Max} = (0.213)(390) = 84$ volts which is below the rating for the 2N3055 of 100 volts [13]. The $V_{EB\ Max}$ is rated at 7.0 VDC and is limited in this circuit by VR1 to 4.3 VDC. Thus as long as VR1 does not fail, Q1 will withstand lightning induced pulses of 1000 volts to terminal 1TB1-1. A similar situation applies to Q2 (JAN 2N3055) in that the maximum current, collector to emitter, is also limited by R7. The peak forward surge power will then also be $\sim$ 0.213 watts, well below the withstand level. The V_{CB} is limited by VR2 to 4.3 VDC and the V_{EB} by R5 (27 ohms) to $(0.213A)(27\Omega) = 5.7$ volts. Both of these values are well below the ratings and Q2 also does not need additional protection as long as VR2 does not fail.

The reference diodes VR1 and VR2 (JAN 1N749A) also have their maximum current limited by R7 to $\sim$ 0.21 amps, and each would need to dissipate a peak power of $(4.3)(0.21) = 0.9$ watts in the regulating direction. In the forward direction, assuming a maximum voltage drop of $\sim$ 1.0 volt across the diode, the diodes would each have to dissipate $\sim$ 0.21 watts. Both of these are below the withstand levels of the JAN 1N749A, but for absolute safety, the peak current should be limited to 85MA [13], which means the voltage at 1TB1-1 should never exceed $\pm$ 400 volts.

The indicator lamps DS-1 through DS-10 are also connected to 1TB1-1 through R7 and from there to ground through a JAN 2N1711 and/or a 180 ohm resistor. The current is thus limited by R7, the lamp, and the 180 ohm series resistor to a maximum of $(1000)/(4700 + 700 + 180) = 0.18$ amps, and the peak power dissipated by each lamp is then $\sim$23 watts. However, if the surge voltage at 1TB1-1 is limited to $\pm$ 400 volts, then each lamp is only $\sim$ 3.6 watts which would be an acceptable level and would not fail the lamps.

As mentioned above, each lamp, DS-2 through DS-10 is switched by a JAN 2N1711 transistor as shown in Figure 3.4-2 of the Alarm Assembly Card. The current through the lamp passes through the emitter-collector circuit and is

limited to 0.18 amp peak for a 1000 volt surge pulse. When the JAN 2N1711 is fully saturated ($V_{CE} \sim 1.0$ volt) the max. peak power dissipated will be $\sim$ 0.18 watts which is much less than the peak power withstand level. If the transistor is turned off, then the peak voltage applied to the 2N1711 is through the voltage divider created by the Lamp DS-1, its 180 ohm resistor, and R7. For a 1000 volt surge, this peak voltage would be $\sim$ 160 volts whereas the breakdown voltage rating on the 2N1711 is BV_{CE} = 30 volts. The power dissipated then would be (30V)(0.18 A) = 5.4 watts which is less than the withstand level of the 2N1711. However, for absolute protection to prevent reverse breakdown, if the voltage surges at 1TB1-1 are limited to $\pm$ 190 volts, then BV_{CB} is never exceeded. This will also protect the collector to base junction since BV_{CB} = 75 volts.

The base-emitter junction of 3A3-Q1 (JAN 2N1711) Signal Processor Assembly (see Figure 3.4-4) is also vulnerable to surges since the base is connected directly to cable W4. The current through the base-emitter circuit is limited by R53 (22 Kohms) and R54 (180 ohms) to $\sim$ 0.045 amps for a peak power of $\sim$45mW when the transistor is saturated. In the reverse direction, BV_{BE} = 7 VDC for a maximum peak power of $\sim$ 0.32 watts. Both power levels are below the withstand levels for JAN 2N1711 but for absolute protection, the terminal 1TB1-1 should be prevented from going negative.

The last vulnerable component at this terminal is diode 3A3-CR4 (JAN 1N4148) on the Signal Processor Assembly (see Figure 3.4-4). However, the current through this diode is limited by R50 (100 KΩ) to a maximum of 10 mA in the forward direction (minimum peak power $\sim$ 10mW) which is well below the withstand level for this diode. In the reverse direction, the maximum voltage applied would be through the voltage divider of R50 (100KΩ) and R51 (100KΩ). Since the peak inverse voltage (PIV) of the 1N4148 is 100 volts, then limiting the peak voltage at 1TB1-1 to less than 200 volts would keep the voltage at the 1N4148 below the PIV.

The Protection Requirements at 1TB1-1 for the worse case are to limit the voltage to +190 volts and -7 volts. A unipolar avalanche diode, with a breakdown voltage of $\sim$ 190 volts such as the leadless transient suppressor GZ 41115P listed in Appendix C, would be adequate protection. However, since the maximum peak pulse current through this diode is 5.2 amps, a series resistance of $\sim$ 160 Ω must be installed in the line to limit the current as explained in Section 2.3 of this report. It is felt that this value of resistance would interfere with the normal

functioning of the line and a lower value of series resistance is necessary. Accordingly installing a GZ 41114Z diode with breakdown voltage of $\sim$ 55 volts and maximum peak current of 18.6 amps requires only a 51 Ω, 2 watt resistor for current limiting. This diode resistor combination will furnish more than adequate protection and will not interfere with normal operations of the line connected to terminal 1TB1-1. This diode and resistor combination and point of installation are shown in Table 4-1.

The connection of Cable W4 to 1TB1-3 allows surge pulses to reach transistors 3A4-Q1 (2N1711) on the Timing Assembly Card (see Figure 3.4-5). Collector-emitter current is limited by R28 (1K Ω) to a peak of 1.0 amp for a surge pulse of 1000 volts peak, provided C16 does not fail (20 WVDC). The peak power in the forward direction is then $\sim$ 1.0 watt and $\sim$ 30 watts in the reverse direction (BV_{CE} = 30 VDC). This latter value is above the withstand level of 24 watts for the 2N1711 and this terminal 1TB1-3 should be protected to limit the peak voltage to $<$ 500 volts peak. However, if C16 fails by shorting, then nothing limits the current flow through 3A4-Q1, and the voltage across R28 should be prevented from exceeding more than twice the working voltage of the capacitor. This can be done by limiting the surge voltage to $\pm$ 40 volts peak by a bipolar avalanche diode at 1TB1-3. In addition C15 (10 μfd, 20 WVDC) will be protected by this diode as will be Q1 and Q2 (JAN 2N3055), and VR2 (JAN 1N749A) in the +8 volt supply on the monitor mainframe, and C12 (20 WVDC), C11 (20 WVDC) and 3A6-VR1 (JAN 1N748A) in the -4 volt power supply regulator circuit on the Alarm Assembly Card. The avalanche diode to protect 1TB1-3 is the bipolar GZ 41116H which has a breakdown voltage of $\sim$ 35 volts and a maximum peak current of 29 amps. This requires a series resistance of 33 ohms. Further the GZ 41116H has a capacitance of $\sim$ 2.4 nfd which should not disturb the operations of the line connected to 1TB1-3, nor should the 33 ohm series resistor (see Table 4-1). An additional bipolar diode is installed at terminal 1TB1-4 which is the return line for the Zero Reference Pulse. This line is left floating at the terminal but grounded internally. A GZ 41115Q bipolar protector with the lowest breakdown voltage available ($\sim$ 7 volts) and a maximum peak pulse current of 139 amps is installed along with a series resistance of 10 ohms to prevent surge voltages from reaching the interior of the localizer monitor circuits while not interferring with the operation of the equipment. An additional 10 ohm resistor is used to trigger the diode (see Table 4-1).

Terminal 1TB1-5 leads to Course Channel Signal Processor components 3A1-U1A (MC 1558 GH2), and 3A1-VR1 (1N748A), (see Figure 3.4-4). The withstand level of the MC 1558 GH2 integrated circuit could not be determined but the maximum input differential voltage should not exceed the maximum supply voltage $\pm$ 8 volts DC. The voltage regulator diode 3A1-VR1 is adequately protected from current surges by R2 (39KΩ). The peak voltage at terminal 1TB1-5 should then be limited by a protective diode but the capacitance of the diode and the value of the series resistor should not interfere with the normal operation of the line. The lowest capacitance available is for the GZ 60316B diode which has a breakdown voltage of $\sim$ 6.8 volts, a maximum peak current of 70 amps and a capacitance at 0 volts of 250 pF. A series current limiting resistor is required to protect the diode. The same diode is installed in the ground returns (terminal 1TB1-6) with an additional 15 ohm series resistor to protect the internal grounding of the monitor mainframe (see Table 4-1). The identical situation occurs with terminals 1TB1-7 and -8 (Width Detected Signal In and Ground Return) as with terminals 1TB1-5 and -6 above, and the same protection requirements are listed in Table 4-1.

Terminal 1TB1-10 leads to the Antenna Cable Fault Zero Reference 500 Hz sine wave generators which includes 3A8-U3B (MC1558GH2) and 3A8-U2 (CD 4016 AD3). As mentioned above, the voltage level to the MC1558GH2 should be limited to $\pm$ 22 volts, but should be limited to $\pm$ 20 volts for the CD4016AD3. The recommended protective diode is a GZ 41116A (Bipolar) with a series resistor of 20 ohms. The connection to terminal 1TB1-11, the return for the zero reference, is also protected as mentioned above.

Three pairs of terminals, 1TB1-13 and 14, -15 and 16, and -17 and 18 have protection requirements similar to terminals 1TB1-5 and 6, and -7 and 8. However, it is felt that the capacitance effects are not as critical on these three pairs because of the higher signal levels, and standard bipolar diodes are recommended for these lines (see Table 4-1). Protection on terminals 1TB1-17 and 18 need only be installed if the cable is connected to these terminals. This completes the protection requirements for components connected to Cable W4 in the Localizer Station at the Shelter end of the cable. The recommended protector diodes, series resistors and installation points are shown in Table 4-1. The other end of Cable W4 terminates at the Antenna Array and the protection requirements for components in the Antenna Array will be discussed in this next section.

The other end of Cable W4 terminates at terminal block 6TB1. Terminals 6TB1-1 and 2 connect to the Antenna Misalignment Switch. Protection of this switch requires limiting the current to 1 amp. This can be done by the combination of a GZ 41114Z diode with a breakdown voltage of $\sim$55 volts, a series 56 ohm resistor to limit the current to the switch and a 56 ohm resistor to limit the current through the diode, (see Table 4-2).

Terminals 6TB1-3 and 4 connect to the Course and Width Integral detectors which requires that diodes CR1 and CR2 (HP 5082-3077) be protected (see Figure 3.4-7). The current through CR1, by way of terminals B and C of the integral detector, is limited by R5 (2.2 K ohm), to 45 mA peak and the current through CR2 is limited by R6 (150 ohm) to 6.7 amps peak for a 1000 volt peak surge. In the forward direction, ($\sim$ 1.0 volts across each diode), CR1 would have to dissipate 0.45 watts peak and CR2, 6.7 watts. This exceeds the rating for CR2 (1.6 watts) and the voltage surge at 6TB1-3 must be limited to -15 volts. In the reverse direction, the peak power dissipated in CR2 (BV = 200 volts), would be $[(1000-200)/150]200 = 1,066$ watts. However, if the voltage at 6TB1-3 is held to less than +200 volts, CR2 will not break down. The protection requirement, can be satisfied by a bipolar diode with breakdown voltage of $\pm$ 15 volts (GZ 41115Y), which requires a 15 ohm current limiting resistor (see Table 4-2). The reference pulse return line (6TB1-4) is protected in the same manner as mentioned previously.

Terminals 6TB1-5 and 6TB1-7 connect to the output of the Course and the Width Integral Detectors respectively. In each case the vulnerable component is CR3 (HP 5082-2800) through terminal D of the detector. The low pass filter combination of C5-L3-C6 provides no protection from lightning pulses of the 10 x 1000 shape for CR3 and thus a series resistor must be included in the protective circuit to limit the current through the diode without disturbing the operation of the circuit. Since the withstand level of the HP 5082-2800 is 4.6 watts and the forward voltage is $\sim$ 1/volt, the current should be limited to $\sim$ 4.6 amps. Further, the reverse voltage applied to the diode should be less than 70 volts to prevent breakdown. A complication with these leads is that the circuit is sensitive to additional capacitance as well as to additional resistance on the lines. The method employed at the other end of these lines will be employed here, namely low capacitance protective diodes, GZ 60316B, with an additional series resistance

of 15 ohms to limit the current through CR3 (see Table 4-2). Terminals 6TB1-6 and -8 are returns for terminals -5 and -7 and are protected in the same manner.

Terminals 6TB1-10 and -11 lead to the Cable Fault Integral Detectors U3, U4 and U5 in the same manner as 6TB1-3 and -4. The protection recommended is the same as for 6TB1-3 and -4. Protection requirements for terminals 6TB1-13, -15 and -17 are the same as for 6TB1-5 and -7 but the lines to -13, 15 and -17 are not as sensitive to additional capacitance as for -5 and -7 and standard diodes are recommended. The same protection is installed in the return lines, terminals 6TB1-14, -16, and -18, for reasons given earlier. This completes the protection requirements for cable W4 at the Antenna Array Termination. The recommended protection is listed in Table 4-2. This also completes the recommended protection for the Localizer Station.

4.2 Glide Slope Station

Cables W8 and W9 connect through terminal block 13TB1 to the Glide Slope Monitor. A typical installation of 13TB1 is shown in Figures 4.2-1A and B. The connection to terminal 13TB1-1 is almost identical to the connection to terminal 1TB1-1 in the Localizer Station. The exception is that since the Tower Tilt Switch is normally open, terminal 3TB1-10 is not wired to 3TB1-9 on the G.S. Monitor as it is in the Localizer Monitor (see Table 3.4-3). However, if the surge is sufficient to arc over the switch or if the switch is closed at the time of the lightning strike, then the same components are vulnerable as for the Localizer Monitor. For this reason, the same protective devices are recommended for both terminals 13TB1-1 and 13TB1-2, (see Table 4-3).

The connection of Cable W9 to terminal 13TB1-3 leads to the same vulnerable components in the Glide Slope Monitor as the connection to terminal 1TB1-3 on the Localizer Monitor. Since the circuits are identical, the recommended protection is identical (see Table 4-3). However, the connection from terminal 3 to Path Integral Detector U1 and Width Integral Detector U2 should be made from the protected side of R1 and not connected directly to Cable W9. Terminal 13TB1-4 is the return for 13TB1-3 and is also protected as previously explained.

The connection of Cable W8 to 13TB1-9 leads to the same vulnerable components as did the connection to terminal 1TB1-5 in the Localizer Station. The protection recommended is the same, including the ground return terminal,

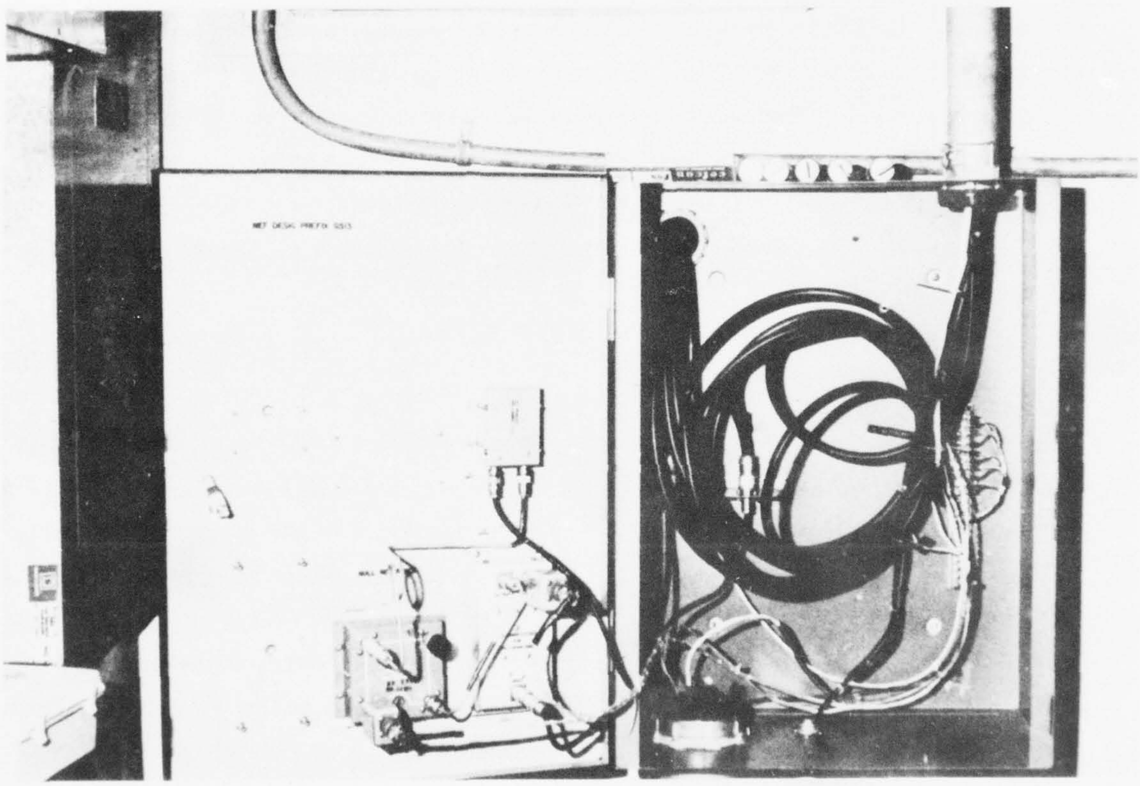

Figure 4.2-1A: Typical Installation of Glide Slope Terminal Block 13TB1

AD-A043 907 ROME AIR DEVELOPMENT CENTER GRIFFISS AFB N Y F/G 17/7
FAA LIGHTNING PROTECTION STUDY: LIGHTNING PROTECTION REQUIREMEN--ETC(U)
MAY 77 M D DRAKE DOT-FA72WAI-356

UNCLASSIFIED FAA-RD-77-102 NL

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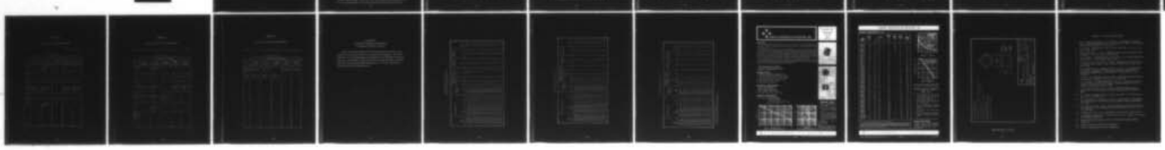

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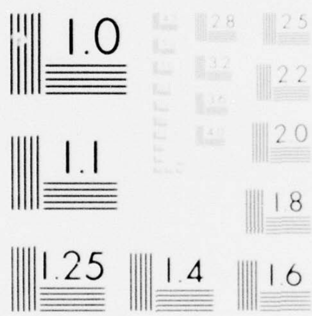


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Figure 4.2-1B: Closeup View of Installation of Glide Slope Terminal Block 13TB1.

13TB1-10. Here again the circuits are sensitive to additional capacitance and resistance, so the recommended protectors are the special low capacitance diodes (see Table 4-3). This completes the recommended protection for the Glide Slope Station circuits located in the shelter. The remaining vulnerable circuits are in the Monitor Detector/Antenna and the Tower Tilt Switch.

The other end of Cable W8 connects to the Monitor Detector/Antenna unit which is a modified Integral Detector. The vulnerable components are the same as for Integral Detectors in the Localizer Station Antenna Array. Terminals C, B, D, and A in the plug-jack W8P1-9J1 of the Glide Slope unit correspond directly to terminals 3, 4, 5, and 6 in terminal block 6TB1 of the Localizer Unit. The recommended protection is the same as for the Localizer unit but the protective devices for the Monitor Detector/Antenna Unit listed in Table 4-4 must be installed in a separate terminal block inside a junction box added between Cable W8 and the plug-jack connector W8P1-9J1.

The last vulnerable component in the Glide Slope Station is the Antenna Tower Tilt Switch, Unit 15. This is a pendulum type, normally open, whose current rating is $\sim$ 1 amp when closed. The protective circuit resistance should be kept below an additional 200 ohms. [16]. The recommended protection on the line which is normally at +28 volts (terminal A in W9P1-15J1) is to limit the voltage to +55 volts, -0 volts and the current through the switch, when closed, to $\sim$ 1 amp. Since the switch is normally open, a protective diode is added in the return line as previously mentioned (see Table 4-5). Installation of the recommended protective devices will require a seperate terminal block in a junction box added between Cable W9 and the plug-jack connector W9P1-15J1 at the Antenna Tower Tilt Switch, Unit 15.

4.3 Installation

The recommended devices for the protection of the Wilcox 1/D ILS Localizer and Glide Slope Stations utilizing the leadless transient suppressor diodes is given in Tables 4-1 through Table 4-5. A terminal block designed to accept the leadless transient suppressor diodes of Appendix C is available and is shown in Figure 4.3-1 [17]. These blocks are available in units to hold up to 10 diodes. A typical installation is shown in Figure 4.3-2 with two series resistors installed. When installing the protective diode circuits, a separate, direct, ground connection should be provided to at each terminal block to insure proper operation of the protective circuits.

Table 4-1
WILCOX 1/D LOCALIZER STATION
SHELTER
Recommended Protection and Installation Points

SIGNAL NAME/ ORGIN	NOMINAL OPERATING VOLTAGE		R1 (ohms)	PROTECTOR P1				TERMINAL BLOCK TB1 Pin	R2 (ohms)	VULNERABLE CIRCUITS AND COMPONENTS	FIGURE NUMBER
	Min	Max		V_R (volts)	V_{BD} (volts)	I_p@25°C (amps)	TYPE				
ANT. MISALIGN. SIGNAL.	0	28	51	45.4	50.4-61.6	18.6	GZ 4114Z	1	--	Localizer Monitor CR1, DS1 thru DS-10, 3A6-Q6 thru -Q10 3A8-Q2, 3A3-Q1 and CR4	3.4-1, -2, -3, -4
ANT. MISALIGN. SIGNAL GROUND	0	0	--	--	--	--	--	2	--	Localizer Monitor Chassis Ground.	3.4-1
ZERO REF. PULSE OUT	-4	+8	33	29	32.4-39.6	29	GZ 41116H (Bipolar)	3	--	Localizer Monitor, Q1 and Q2 Timing Assembly, Q1, VR1 (2N1711) (JAN 1N748A)	3.4-1, -5, -2
ZERO REF. PULSE OUT GROUND	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	4	10	Localizer Monitor Timing Assembly Ground	3.4-5
COURSE DETECTED SIGNAL IN	0	200 mV AC	15	5.0	6.66-8.14	70	GZ 60316B	5		Localizer Monitor Course, Channel Signal Processer Assby. U1A(MC1558), VR1 (IN748A)	3.4-4
COURSE DETECTED SIGNAL IN GND. RETN.	0	0	15	5.0	6.66 8.14	70	GZ 60316B	6	15	Localizer Monitor Course Channel Sig. Proc. Assy. Chassis Ground	3.4-4
WIDTH DETECTED SIGNAL IN.	0	260 mV AC	15	5.0	6.66-8.14	70	GZ 60316B	7		Localizer Monitor Width Channel Sig. Proc. Assy. U1A (MC1558), VR1(1N748A)	3.4-4
WIDTH DETECTED SIGNAL IN GND. RETN	0	0	15	5.0	6.66-8.14	70	GZ 60316B	8	15	Localizer Monitor Width Channel Sig. Proc. Assy. Chasis Ground	3.4-4

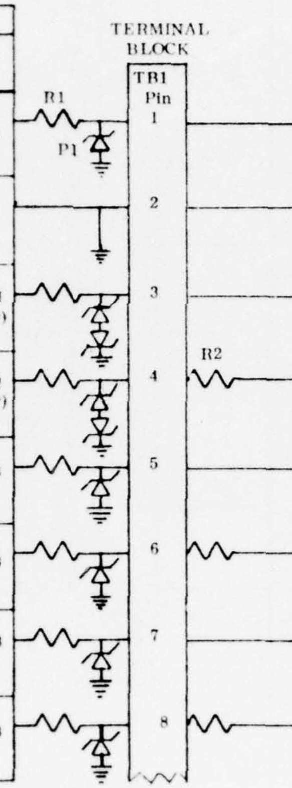
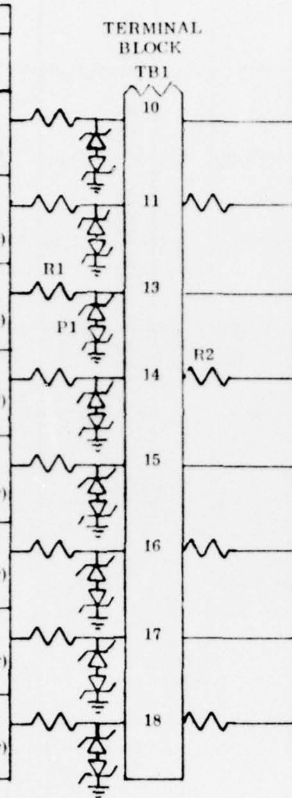


Table 4-1 (continued)
WILCOX I/D LOCALIZER STATION
SHELTER

SIGNAL NAME/ ORIGIN	NOMINAL OPERATING VOLTAGE		R1 (ohms)	PROTECTOR P1				R2 (ohms)	VULNERABLE CIRCUITS AND COMPONENTS	FIGURE NUMBER
	Min	Max		V_R (volts)	V_{BD} (volts)	I_P@25°C (amps)	TYPE			
ZERO REF. PULSE OUT (cable fault)	0	8VAC	20	14.5	16.2-19.8	56.5	GZ 41116A (Bipolar)	--	Localizer Monitor Antenna Cable Fault Assy. U3B (MC 1558 G) U2 (CD 4016)	3.4-3
ZERO REF. PULSE OUT (gnd. retn.)	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	10	Localizer Monitor Antenna Cable Fault Assy. Ground Return	3.4-3
CABLE FAULT DETECTOR U3	0	320 mV AC	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	--	Localizer Monitor Antenna Cable Fault Assy. U1B (MC 1558G) VR1 (1N748A)	3.4-3
CABLE FAULT DETECTOR U3 Gnd. Retn.	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	10	Localizer Monitor Antenna Cable Fault Assy. Chassis Ground	3.4-3
CABLE FAULT DETECTOR U4	0	320 mV AC	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	--	Localizer Monitor Antenna Cable Fault Assy. U1A (MC 1558G) VR1 (1N748A)	3.4-3
CABLE FAULT DETECTOR U4 Gnd. Retn.	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	10	Localizer Monitor Antenna Cable Fault Assy. Chasis Ground	3.4-3
CABLE FAULT DETECTOR U5	0	320 mV AC	10*	5.50	6.12-7.48	139	GZ* 41115Q (Bipolar)	--	Localizer Monitor Antenna Cable Fault Assy. U4A(MC 1558G) VR1 (1N748A)	3.4-3
CABLE FAULT DETECTOR U5 Gnd. Retn.	0	0	10*	5.50	6.12-7.48	139	GZ* 41115Q (Bipolar)	10*	Localizer Monitor Antenna Cable Fault Assy. Chasis Ground	3.4-3



* Install only if cable to antenna array is present and wired to monitor.

Table 4-2
WILCOX 1/D LOCALIZER STATION
ANTENNA ARRAY
Recommended Protection and Installation Points

SIGNAL NAME/ ORIGIN	NOMINAL OPERATING VOLTAGE		R1 (ohms)	PROTECTOR P1				R2 (ohms)	VULNERABLE CIRCUITS AND COMPONENTS	FIGURE NUMBER
	Min	Max		V_R (volts)	V_{BD} (volts)	I_P@25°C (amps)	TYPE			
ANT. MISALIGN SWITCH	0	28	56	45.4	50.4-61.6	18.6	GZ 41114Z	56	Antenna Misalighment Switch	3.4-6
ANT MISALIGN SWITCH GROUND	0	0	--	--	--	--	--	--	Antenna Misalignment Switch	3.4-6
ZERO REF PULSE IN	-4	+8	15	12.1	13.5-16.5	68	GZ 41115Y (Bipolar)	--	Course Integral Detector Width Integral Detector HP 5082-3077 (CR1 and CR2)	3.4-6, -7
ZERO REF PULSE IN GROUND RETURN	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	10	Course and Width Integral Detectors HP5082-3077 and -2800	3.4-6, -7
COURSE DETECTED SIGNAL	0	200mV AC	15	5.0	6.66-8.14	70	GZ 60316B	15	Course Integral Detector HP5082-2800 (CR3)	3.4-6, -7
COURSE DETECTED SIGNAL GROUND	0	0	15	5.0	6.66-8.14	70	GZ 60316B	15	Course Integral Detector Chasis Ground	3.4-6, -7
WIDTH DETECTED SIGNAL	0	200mV AC	15	5.0	6.66-8.14	70	GZ 60316B	15	Course Integral Detector HP5082-2800 (CR3)	3.4-6, -7
WIDTH DETECTED SIGNAL GROUND	0	0	15	5.0	6.66-8.14	70	GZ 60316B	15	Course Integral Detector Chasis Ground	3.4-6, -7

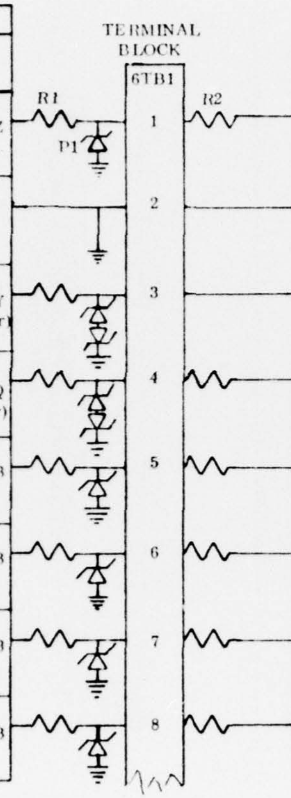
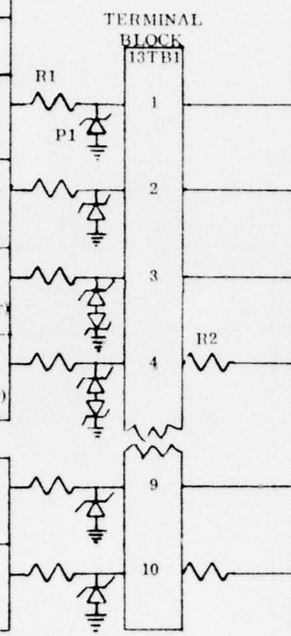


Table 4-2 (continued)
WILCOX 1/D LOCALIZER STATION
ANTENNA ARRAY

SIGNAL NAME/ ORIGIN	NOMINAL OPERATING VOLTAGE		R1 (ohms)	PROTECTOR P1				TERMINAL BLOCK 6TB1	R2 (ohms)	VULNERABLE CIRCUITS AND COMPONENTS	FIGURE NUMBER
	Min	Max		V_R (volts)	V_{BD} (volts)	I_p@25°C (amps)	TYPE				
ZERO REF. PULSE (CABLE FAULT)	0	8VAC	15	12.1	13.5-16.5	68	GZ 41115Y (Bipolar)	10	--	Cable Fault Detectors U3, U4, U5 HP5082-3077 (CR1 and CR2)	3.4-6, -7
ZERO REF. PULSE GROUND RETURN	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	11	10	Cable Fault Detectors U3, U4, U5 HP5082-3077 and -2800 CR1 and CR3	3.4-6, -7
DETECTED SIGNAL FROM U3	0	320 mV AC	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	13	10	Cable Fault Detector U3 HP5082-2800 CR3	3.4-6, -7
DET. SIG. FROM U3 GROUND	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	14	10	Cable Fault Detector U3 Detector Ground	3.4-6, -7
DETECTED SIGNAL FROM U4	0	320 mV AC	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	15	10	Cable Fault Detector U4 HP5082-2800 CR3	3.4-6, -7
DETECTED SIGNAL FROM U4 GROUND	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	16	10	Cable Fault Detector U4 Detector Ground	3.4-6, -7
DETECTED SIGNAL FROM U5	0	320 mV AC	10*	5.50	6.12-7.48	139	GZ* 41115Q (Bipolar)	17	10	Cable Fault Detector U5 HP5082-2800 CR3	3.4-6, -7
DETECTED SIGNAL FROM U5 GROUND	0	0	10*	5.50	6.12-7.48	139	GZ* 41115Q (Bipolar)	18	10*	Cable Fault Detector U5 Detector Ground	3.4-6, -7

Table 4-3
WILCOX 1/D GLIDE SLOPE STATION
SHELTER
Recommended Protection and Installation Points

	SIGNAL NAME/ ORIGIN	NOMINAL OPERATING VOLTAGE		R1 (ohms)	PROTECTOR P1				TERMINAL BLOCK 13TB1	R2 (ohms)	VULNERABLE CIRCUITS AND COMPONENTS	FIGURE NUMBER
		Min	Max		V_R (Volts)	V_{BD} (volts)	I_p @25°C (amps)	TYPE				
Note 1	ANTENNA TOWER TILT	0	28	56	45.4	50.4-61.6	18.6	GZ 41114Z	1	--	Glide Slope Monitor CR1, DS-1 through DS-10. 3A6-Q6 through Q10 (alarm assy) 3A3-Q1 and CR4 (sig. proc. assy).	3.3-2 3.4-8 3.4-2A 3.4-4
	ANTENNA TOWER TILT RETURN	0	28	56	45.4	50.4-61.6	18.6	GZ 41114Z	2	--	Glide Slope Monitor Signal Processor Assy. 3A3-Q1 and CR4	3.4-4
Note 2	ZERO REF. PULSE OUT	-4	+8	33	29	32.4-39.6	29	GZ 41116H (Bipolar)	3	---	Glide Slope Monitor Timing Assembly 3A4-Q1 Alarm Assy. - 3A6-VR1	3.4-8, 3.4-5 3.4-2B
Note 3	ZERO REF. PULSE OUT GROUND	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	4	10	Glide Slope Monitor Timing Assembly Chassis Ground	3.4-5
	PATH DETECTED SIGNAL IN (near field)	0	200mV AC	15	5.0	6.66-8.14	70	GZ 60316B	9	--	Glide Slope Monitor Near Field Path Sig. Processor Assy., 3A3-U1A & VR1	3.4-8, 3.4-4
	PATH DETECTED SIGNAL IN (nr field gnd)	0	0	15	5.0	6.66-8.14	70	GZ 60316B	10	15	Glide Slope Monitor Near Field Path Signal Processor Assy. Chassis Ground	3.4-8, 3.4-4



Note 1: Cable W9, shown in Figure 11-5 as a single lead shielded audio cable has been replaced with 3 wire twisted shielded audio cable. In this case, the black lead serves as the signal return to terminal 2. Protection remains the same.

Note 2: Connections from Terminal 3 to Path Integral Detector U1 and Width Integral Detector U2 should be made from the protected side of R1 and not connected directly to the lines from the Monitor Detector/Antenna.

Note 3: Ground Connections to U1 and U2 should be made between R2 and the Glide Slope Monitor and Not directly from Term4.

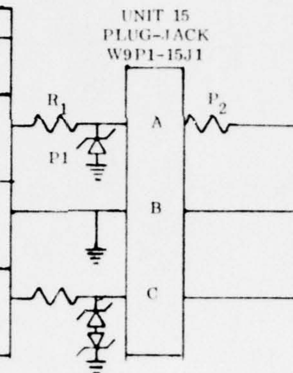
Table 4-4
WILCOX 1/D GLIDE SLOPE STATION
MONITOR DETECTOR/ANTENNA
UNIT 9
Recommended Protection and Installation Points

SIGNAL NAME/ ORIGIN	NOMINAL OPERATING VOLTAGE		R1	PROTECTOR P1				PLUG-JACK W8P1-9J1 (see Note)	R2	VULNERABLE CIRCUITS AND COMPONENTS	FIGURE NUMBER
	Min	Max	(ohms)	V_R (volts)	V_{BD} (volts)	I_P @25°C (amps)	TYPE		(ohms)		
ZERO REF. PULSE IN	-4	+8	15	12.1	13.5-16.5	68	GZ 41115Y (Bipolar)	C	--	Near Field Monitor Detector CR1 and CR2 HP5082-3077	3.3-2, 3.4-9
ZERO REF. PULSE IN RETURN	0	0	10	5.50	6.12-7.48	139	GZ 41115Q (Bipolar)	B	10	Near Field Monitor Detector, Chasis Ground	3.3-2, 3.4-9
DETECTED OUTPUT SIGNAL	0	200mV AC	15	5.0	6.66-8.14	70	GZ 60316B	D	15	Near Field Monitor Detector, CR3 (HP5082-2800)	3.3-2, 3.4-9
DETECTED OUTPUT GROUND	0	0	15	5.0	6.66-8.14	70	GZ 60316B	A	15	Near Field Monitor Detector, Chasis Ground	3.3-2, 3.4-9

Note: The protective devices shown here must be installed in a seperate terminal block and junction box added between cable W8 and the plug-jack connector W8P1-9J1 at the Monitor Detector/Antenna Unit 9.

Table 4-5
WILCOX 1/D GLIDE SLOPE STATION
ANTENNA TILT SWITCH
Recommended Protection and Installation Points

SIGNAL NAME/ ORIGIN	NOMINAL OPERATING VOLTAGE		R1	PROTECTOR P1				R2	VULNERABLE CIRCUITS AND COMPONENTS	FIGURE NUMBER
	Min	Max	(ohms)	V_R (volts)	V_{BD} (volts)	I_p@25°C (amps)	TYPE	(ohms)		
ANT. TILT SWITCH/ 28V SUPPLY	0	28	56	0	0	0	GZ 41114Z	56	Antenna Tilt Switch	3.3-2
SHIELD	0	0		--	--	--	--	--	Antenna Tilt Switch	3.3-2
ANT. TILT SWITCH RETURN	0	28	10	0	0	0	GZ 41115Q	--	Antenna Tilt Switch	3.3-2



Note 1 Cable W9, shown in Figure 11-5 as a single lead shielded cable has been replaced with a 3 wire twisted shielded audio cable. The black lead serves as the signal return attached to terminal 3.

Note 2 The protective devices shown here must be installed in a seperate terminal block and junction box added between cable W9 and the plug-jack connector W9P1-15J1 at the Antenna Tilt Switch Unit 15.

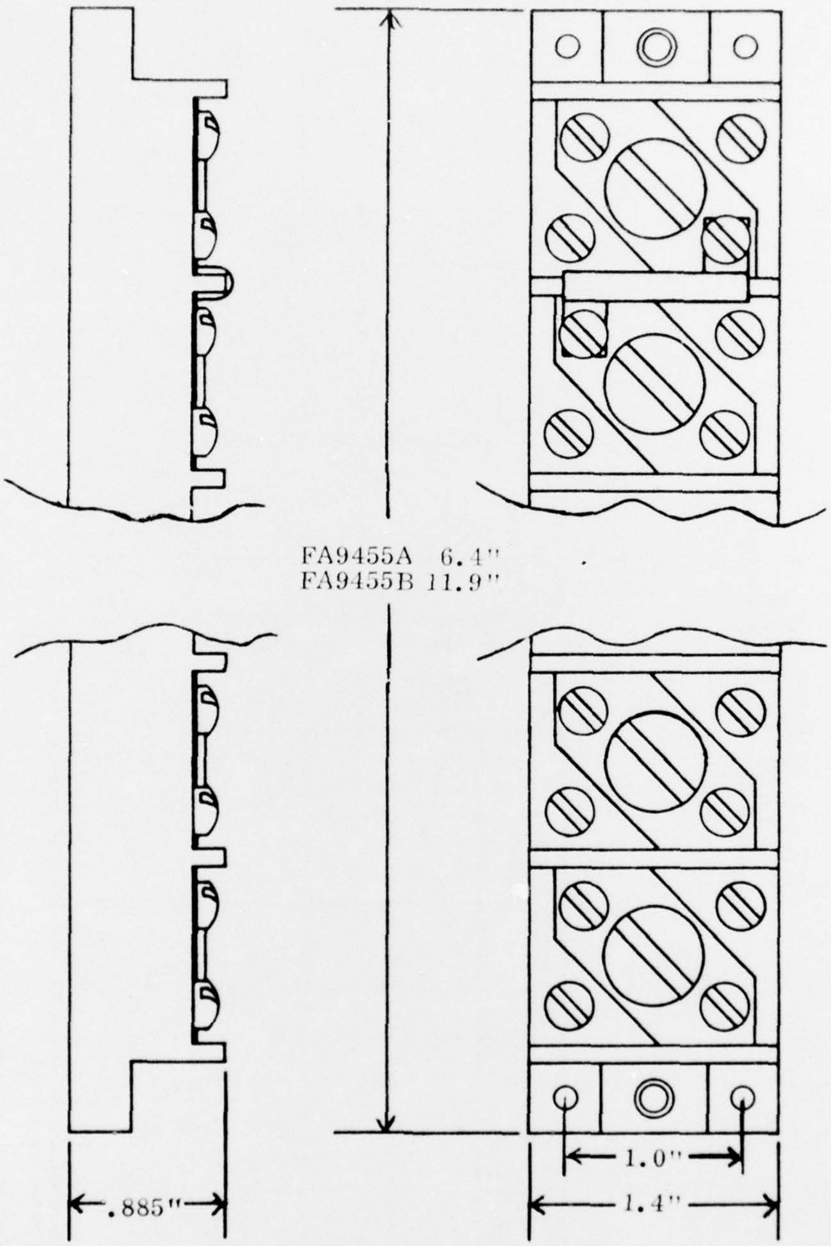


Figure 4.3-1 Lightning Protection Module, Plan View

The plan view gives critical clearance and mounting dimensions. The 5 terminal unit is designated FA 9455A. The 10 terminal is designated FA 9455B. Figure 4.3-2 is a full scale photograph of the FA 9455A showing diode insertion and resistor mounting for the most common arrangements.

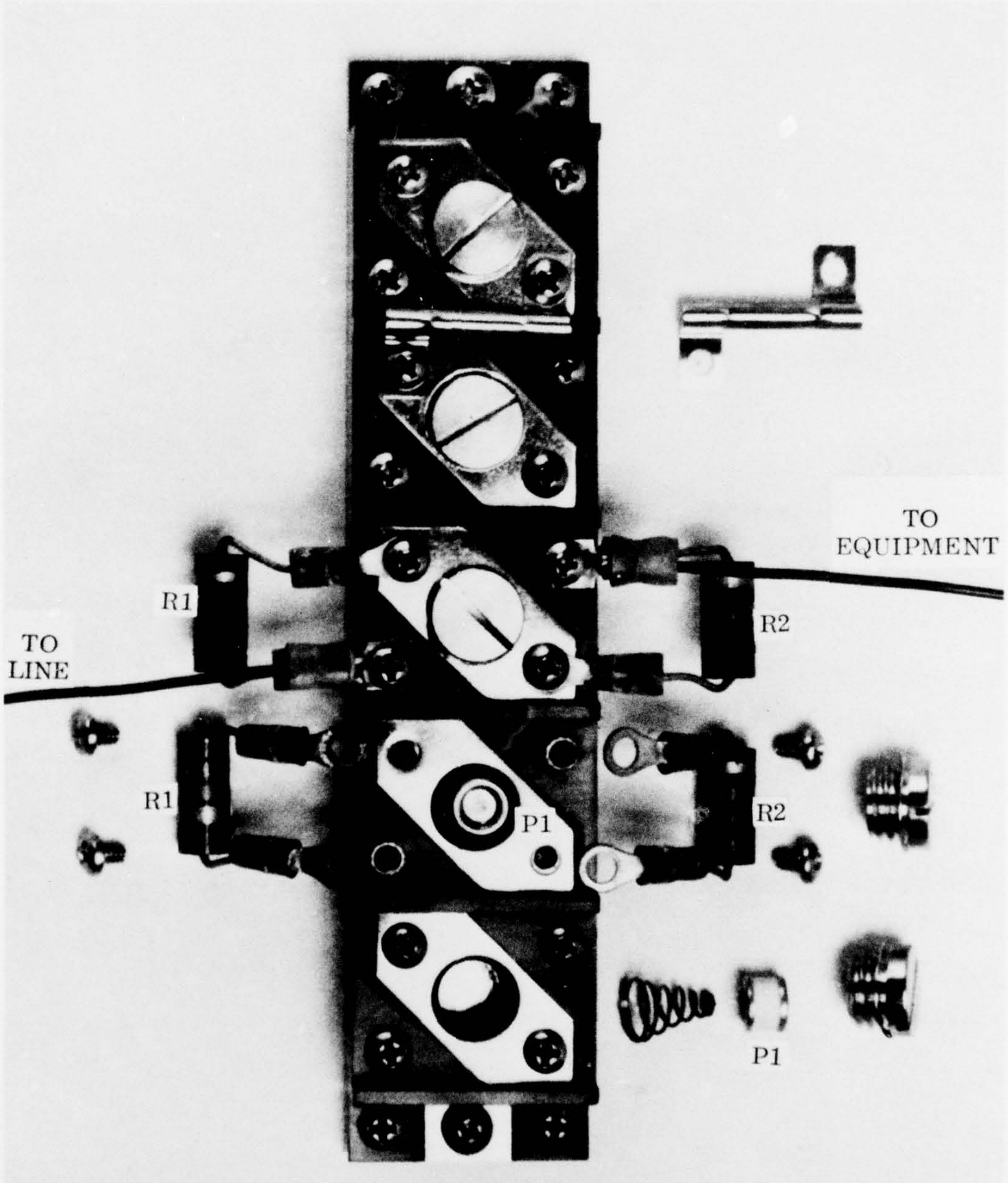


Figure 4.3-2 LPM Type FA 9455 A

Note the crossover connector connecting the top two terminals. This is used in the occasional case where more mounting points are required such as for a series diode.

APPENDIX A

FAA Lightning Study Participants

Florida Institute of Technology - Cable Testing and Equipment Analysis

Dr. Andrew W. Revay, Jr.
Dr. Marvin D. Drake
Richard M. Cosel
Dr. Richard H. Hu

Purdue University - Protective Devices

Warren Peele (Project Leader)
Dr. Chin-Lin Chen

Georgia Institute of Technology - Equipment Analysis

Keith Huddleston
Dr. John Nordgard

Air Force Institute of Technology - Reliability Aspects

Lt. Col. Jerry L. Hanson
Prof. T. L. Regulinski

APPENDIX B

Wilcox 1/D ILS Localizer Station

Functional Index

	INSTRUCTION BOOK REFERENCE				
UNIT	THEORY OF OPERATION	PARTS DESC & LOCATION	ALIGNMENT PROCEDURE	PRECISE ACCESS BLK DIAG	SCHEMATIC DIAGRAM
CABINET 1	NA	Table 8-1 (This Instr Book)	NA	NA	NA
CONTROL UNIT 2	TI6750.82	TI6750.82	TI6750.82	TI6750.82	TI6750.82
MONITOR 3	TI6750.81	TI6750.81	TI6750.81	TI6750.81	TI6750.81
TRANS-MITTER 4	TI6750.91	TI6750.91	TI6750.91	TI6750.91	TI6750.91
RF POWER PANEL 5	Para 2-3 (This Instr Book)	Table 8-2 (This Instr Book	NA	Figure 11-8 (This Instr Book)	Figure 11-10 (This Instr Book)
ANTENNA ARRAY 6	TI6750.92	TI6750.92	TI6750.92	TI6750.92	TI6750.92
POWER SUPPLY 7	TI6750.80	TI6750.80	TI6750.80	TI6750.80	TI6750.80
SHELTER 11	NA	Table 8-3 (This Instr Book)	NA	NA	NA

APPENDIX B

Wilcox 1/D ILS Glide Slope Station

FA-9351/FA-9352/FA-9356/FA-9365/FA-9367/FA-9371/FA-9372/FA-9378 TI6750.78

Functional Index

	INSTRUCTION BOOK REFERENCE				
UNIT	THEORY OF OPERATION	PARTS DESC & LOCATION	ALIGNMENT PROCEDURE	PRECISE ACCESS BLK DIAG	SCHEMATIC DIAGRAM
Equipment Cabinet 1	NA	Table 8-1 (This Instr Book)	NA	NA	NA
Control Unit 2	TI6750.82	TI6750.82	TI6750.82	TI6750.82	TI6750.82
Monitor 3	TI6750.81	TI6750.81	TI6750.81	TI6750.81	TI6750.81
Trans-mitter 4	TI6750.79	TI6750.79	TI6750.79	TI6750.79	TI6750.79
Rf Power Panel 5	Para 2-3.b (This Instr Book)	Table 8-2 (This Instr Book)	NA	Fig. 11-8 (This Instr Book)	Fig. 11-10 (This Instr Book)
Power Supply 7	TI6750.80	TI6750.80	TI6750.80	TI6750.80	TI6750.80
Monitor Detector/ Antenna 9	Para 2-3.c (This Instr Book)	Table 8-5 (This Instr Book)	Para 9-8.d, 9-9.c (This Instr Book)	NA	NA
Antenna 10	TI6750.83	TI6750.83	TI6750.83	TI6750.83	TI6750.83
Shelter 11	NA	Table 8-3 (This Instr Book)	NA	NA	NA
Sideband Reference Amplitude and Phase Control Unit 12	TI6750.84	TI6750.84	TI6750.84	TI6750.84	TI6750.84

APPENDIX B

Wilcox 1/D ILS Glide Slope Station

Functional Index (Cont)

	INSTRUCTION BOOK REFERENCE				
UNIT	THEORY OF OPERATION	PARTS DESC & LOCATION	ALIGNMENT PROCEDURE	PRECISE ACCESS BLK DIAG	SCHEMATIC DIAGRAM
Monitor Combining Network 13	Para 2-3.c (This Instr Book)	Table 8-4 (This Instr Book)	NA	Fig. 11-12, 11-16 (This Instr Book)	Fig. 11-14, 11-18 (This Instr Book)
Tower Tilt Monitor 15	Para 2-3.e (This Instr Book)	Table 8-5 (This Instr Book)	Para 9-11 (This Instr Book)	NA	NA

x

APPENDIX C
LEADLESS TRANSIENT SUPPRESSORS - ELECTRICAL CHARACTERISTICS

Pages C1 through 3 tabulate the electrical characteristics and FAA part numbers for the transient suppressors specified in this handbook. The JEDEC equivalents are not mechanically interchangeable and are included for reference purposes. Also included is a listing of commercial equivalent units also manufactured by General Semiconductor Industries, Inc. Use of the data sheet is with permission of the copyright owner.

LEADLESS TRANSIENT SUPPRESSORS

ELECTRICAL CHARACTERISTICS 25^{o}C

FAA Part No.*	Breakdown Voltage BV Volts	@ I_T mA	Reverse Stand-Off Voltage V_R Volts	Maximum Clamping Voltage @ I_{PP} V_C Volts	Maximum Reverse Leakage @ I_R I_R A	Maximum Peak Pulse Current I_{PP} A	Maximum Temp. Coef. of BV %/^{o}C	Jedec Type No.**
GZ41114B	6.12 - 7.48	10	5.50	10.8	1000	139	.057	1N5629
GZ41116D	Same as GZ41114B	except	Bipolar***					
GZ41114C	6.75 - 8.25	10	6.05	11.7	500	128	.061	1N5630
GZ41115R	Same as GZ41114C	except	Bipolar***					
GZ41114D	7.38 - 9.02	10	6.63	12.5	200	120	.065	1N5631
GZ41115S	Same as GZ41114D	except	Bipolar***					
GZ41114E	8.19 - 10.0	1	7.37	13.8	50	109	.068	1N5632
GZ41115T	Same as GZ41114E	except	Bipolar***					
GZ41114F	9.00 - 11.0	1	8.10	15.0	10	100	.073	1N5633
GZ41115U	Same as GZ41114F	except	Bipolar***					
GZ41114G	9.9 - 12.1	1	8.92	16.2	5	93	.075	1N5634
GZ41115V	Same as GZ41114G	except	Bipolar***					
GZ41114H	10.8 - 13.2	1	9.72	17.3	5	87	.078	1N5635
GZ41115W	Same as GZ41114H	except	Bipolar***					
GZ41114J	11.7 - 14.3	1	10.5	19.0	5	79	.081	1N5636
GZ41115X	Same as GZ41114J	except	Bipolar***					
GZ41114K	13.5 - 16.5	1	12.1	22.0	5	68	.084	1N5637
GZ41115Y	Same as GZ41114K	except	Bipolar***					
GZ41114L	11.4 - 17.6	1	12.9	23.5	5	64	.086	1N5638
GZ41115Z	Same as GZ41114L	except	Bipolar***					
GZ41114M	16.2 - 19.8	1	14.5	26.5	5	56.5	.088	1N5639
GZ41116A	Same as GZ41114M	except	Bipolar***					
GZ41114N	18.0 - 22.0	1	16.2	29.1	5	51.5	.090	1N5640
GZ41116B	Same as GZ41114N	except	Bipolar***					
GZ41114P	19.8 - 24.2	1	17.8	31.9	5	47	.092	1N5641
GZ41116C	Same as GZ41114P	except	Bipolar***					

ELECTRICAL CHARACTERISTICS 25°C

FAA Part No.*	Breakdown Voltage BV Volts	@ I_T mA	Reverse Stand-Off Voltage V_R Volts	Maximum Clamping Voltage @ I_{PP} V_C Volts	Maximum Reverse Leakage @ I_R I_R A2	Maximum Peak Pulse Current I_{PP} A	Maximum Temp. Coef. of BV %/°C	Jedec Type No.**
GZ41114Q	21.6 - 26.4	1	19.4	34.7	5	43	.094	1N5642
GZ41116D	Same as GZ41114Q	except	Bipolar***					
GZ41114R	24.3 - 29.7	1	21.8	39.1	5	38.5	.096	1N5643
GZ41116E	Same as GZ41114R	except	Bipolar***					
GZ41114S	27.0 - 33.0	1	24.3	43.5	5	34.5	.097	1N5644
GZ41116F	Same as GZ41114S	except	Bipolar***					
GZ41114T	29.7 - 36.3	1	26.8	47.7	5	31.5	.098	1N5645
GZ41116G	Same as GZ41114T	except	Bipolar***					
GZ41114U	32.4 - 39.6	1	29.1	52.0	5	29	.099	1N5646
GZ41116H	Same as GZ41114U	except	Bipolar***					
GZ41114V	35.1 - 42.9	1	31.6	56.4	5	26.5	.100	1N5647
GZ41116J	Same as GZ41114V	except	Bipolar***					
GZ41114W	38.7 - 47.3	1	34.8	61.9	5	24	.101	1N5648
GZ41116K	Same as GZ41114W	except	Bipolar***					
GZ41114X	42.3 - 51.7	1	38.1	67.8	5	22.2	.101	1N5649
GZ41116L	Same as GZ41114X	except	Bipolar***					
GZ41114Y	45.9 - 56.1	1	41.3	73.5	5	20.1	.102	1N5650
GZ41116M	Same as GZ41114Y	except	Bipolar***					
GZ41114Z	50.4 - 61.6	1	45.4	80.5	5	18.6	.103	1N5651
GZ41116N	Same as GZ41114Z	except	Bipolar***					
GZ41115A	55.8 - 68.2	1	50.2	89.0	5	16.9	.104	1N5652
GZ41116P	Same as GZ41115A	except	Bipolar***					
GZ41115B	61.2 - 74.8	1	55.1	98.0	5	15.3	.104	1N5653
GZ41116Q	Same as GZ41115B	except	Bipolar***					

ELECTRICAL CHARACTERISTICS 25°C

FAA Part No.*	Breakdown Voltage BV Volts	@ I_T mA	Reverse Stand-Off Voltage V_R Volts	Maximum Clamping Voltage @ I_{PP} V_C Volts	Maximum Reverse Leakage @ I_R I_R A	Maximum Peak Pulse Current I_{PP} A	Maximum Temp. Coef. of BV %/°C	Jedec Type No.**
GZ41115C	67.5 - 82.5	1	60.7	108.0	5	13.9	.105	1N5654
GZ41116R	Same as GZ41115C	except	Bipolar***					
GZ41115D	73.8 - 90.2	1	66.4	118.0	5	12.7	.105	1N5655
GZ41116S	Same as GZ41115D	except	Bipolar***					
GZ41115E	81.9 - 100.0	1	73.7	131.0	5	11.4	.106	1N5656
GZ41116T	Same as GZ41115E	except	Bipolar***					
GZ41115F	90.0 - 110.0	1	81.0	144.0	5	10.4	.106	1N5657
GZ41116U	Same as GZ41115F	except	Bipolar***					
GZ41115G	99.0 - 121.0	1	89.2	158.0	5	9.5	.107	1N5658
GZ41116V	Same as GZ41115G	except	Bipolar***					
GZ41115H	108.0 - 132.0	1	97.2	173.0	5	8.7	.107	1N5659
GZ41116W	Same as GZ41115H	except	Bipolar***					
GZ41115J	117.0 - 143.0	1	105.0	187.0	5	8.0	.107	1N5660
GZ41116X	Same as GZ41115J	except	Bipolar***					
GZ41115K	135.0 - 165.0	1	121.0	215.0	5	7.0	.108	1N5661
GZ41116Y	Same as GZ41115K	except	Bipolar***					
GZ41115L	144.0 - 176.0	1	130.0	230.0	5	6.5	.108	1N5662
GZ41116Z	Same as GZ41115L	except	Bipolar***					
GZ41115M	153.0 - 187.0	1	138.0	244.0	5	6.2	.108	1N5663
GZ41117A	Same as GZ41115M	except	Bipolar***					
GZ41115N	162.0 - 198.0	1	146.0	258.0	5	5.8	.108	1N5664
GZ41117B	Same as GZ41115N	except	Bipolar***					
GZ41115P	180.0 - 220.0	1	162.0	287.0	5	5.2	.108	1N5665
GZ41117C	Same as GZ41115P	except	Bipolar***					

* Fig. 1 for outline drawing.
** Part is similar electrically but mechanically.
*** Electrical characteristics apply in both directions.

GENERAL SEMICONDUCTOR INDUSTRIES, INC.

TRANSZORB

TRANSIENT VOLTAGE SUPPRESSORS

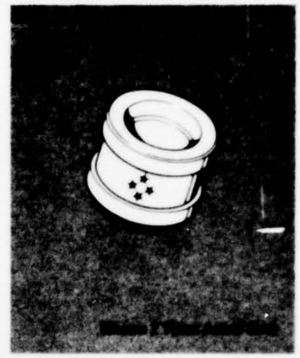
1.5KC6.8 THRU 1.5KC110A

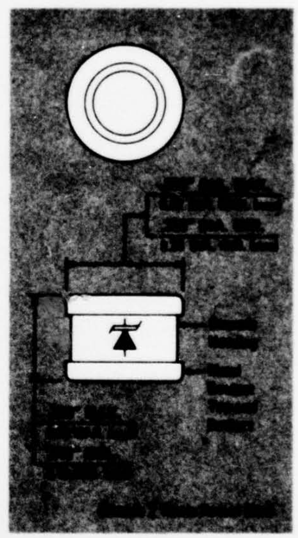
DESCRIPTION

This leadless TransZorb is designed for direct retro-fit or replacement of a gas-discharge suppressor when lower voltages are needed to protect voltage sensitive circuitry. For Bipolar applications, see notes on the reverse side.

The TransZorb has a peak pulse power rating of 1500 watts for 1 millisecond and therefore can be used in applications where induced lightning on rural or remote transmission lines present a hazard to the electronic circuitry. (Reference: R.E.A. Specification P.E. 60). The response time of TransZorb clamping action is effectively instantaneous (better than 1 x 10^{-12} sec.); therefore, they can protect Integrated Circuits, MOS devices, Hybrids and other voltage-sensitive semiconductors and components. TransZorbs can also be used in series or parallel to increase the peak power ratings.

TransZorbs have proven to be effective in Airborne Avionics and Controls, Mobil Communication Equipment, Computer Power Supplies, Numerically Controlled Machinery, and in many other applications where inductive and switching transients are present.





- **1500 watts peak power dissipation**
- **Available in ranges from 6.8V to 110V.**
-

MAXIMUM RATINGS

- 1500 Watts of Peak Pulse Power dissipation at 25°C
- $t_{clamping}$ (0 volts to BV min): Less than 1 x 10^{-12} seconds
- Operating and Storage Temperatures: −65° to +175°C
- Forward surge rating: 200 amps, 1/120 second at 25° C
- Steady State power dissipation: 1.0 W
- Repetition rate (duty cycle): .01%

MECHANICAL CHARACTERISTICS

- Ceramic Case with Metal Caps
- Weight: 1.25 grams (approximate)
- Polarity marked with polarity symbol
- Body marked with Logo and type number

ELECTRICAL CHARACTERISTICS

- Clamping Ratio: 1.33 @ Full rated power
  1.15 @ 50% rated power

Clamping Ratio: The ratio of the actual Vc (Clamping Voltage) to the actual BV (Breakdown Voltage) as measured on a specific device. (See figure 3 for test pulse wave shape.)

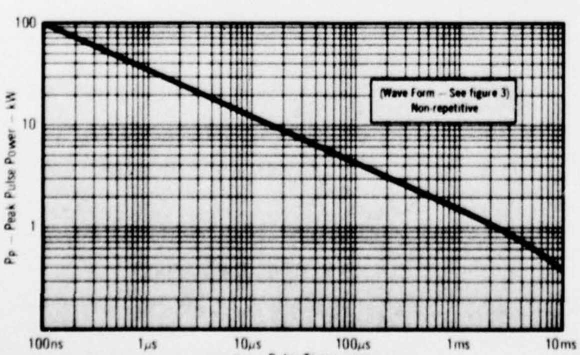


FIGURE 1 — Peak Pulse Power vs Pulse Time

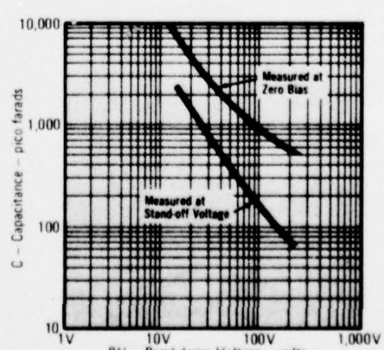


FIGURE 2
Typical Capacitance vs Breakdown Voltage

ABBREVIATIONS & SYMBOLS

V_R Stand Off Voltage: Applied Reverse Voltage to assure a nonconductive condition. (See Note 1)

BV(min) This is the minimum Breakdown Voltage the device will exhibit and is used to assure that conduction does not occur prior to this voltage level at 25°C.

V_C(max) Maximum Clamping Voltage. The maximum peak voltage appearing across the TransZorb when subjected to the peak pulse current in a one millisecond time interval. The peak pulse voltages are the combination of voltage rise due to both the series resistance and thermal rise.

I_{PP} Peak Pulse Current – See Figure 3

P_P Peak Pulse Power

I_R Reverse Leakage

Note 1:
A TransZorb is normally selected according to the reverse "Stand Off Voltage" (V_R) which should be equal to or greater than the DC or continuous peak operating voltage level.

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ELECTRICAL CHARACTERISTICS at 25°C

GENERAL SEMICONDUCTOR PART NUMBER	REVERSE STAND OFF VOLTAGE (See Note 1) V_R VOLTS	BREAKDOWN VOLTAGE BV VOLTS Min	Max	@ I_T mA	MAXIMUM CLAMPING VOLTAGE @ I_{PP} (See Fig. 3) V_C VOLTS	MAXIMUM REVERSE LEAKAGE @ V_R I_R µA	MAXIMUM PEAK PULSE CURRENT (See Fig. 3) I_{PP} A	MAXIMUM TEMPERATURE COEFFICIENT OF BV %/°C
1.5KC6.8	5.50	6.12	7.48	10	10.8	1000	139	.057
1.5KC6.8A	5.80	6.45	7.14	10	10.5	1000	143	.057
1.5KC7.5	6.05	6.75	8.25	10	11.7	500	128	.061
1.5KC7.5A	6.40	7.13	7.88	10	11.3	500	132	.061
1.5KC8.2	6.63	7.38	9.02	10	12.5	200	120	.065
1.5KC8.2A	7.02	7.79	8.61	10	12.1	200	124	.065
1.5KC9.1	7.37	8.19	10.0	1	13.8	50	109	.068
1.5KC9.1A	7.78	8.65	9.55	1	13.4	50	112	.068
1.5KC10	8.10	9.00	11.0	1	15.0	10	100	.073
1.5KC10A	8.55	9.5	10.5	1	14.5	10	103	.073
1.5KC11	8.92	9.9	12.1	1	16.2	5	93	.075
1.5KC11A	9.40	10.5	11.6	1	15.6	5	96	.075
1.5KC12	9.72	10.8	13.2	1	17.3	5	87	.078
1.5KC12A	10.2	11.4	12.6	1	16.7	5	90	.078
1.5KC13	10.5	11.7	14.3	1	19.0	5	79	.081
1.5KC13A	11.1	12.4	13.7	1	18.2	5	82	.081
1.5KC15	12.1	13.5	16.5	1	22.0	5	68	.084
1.5KC15A	12.8	14.3	15.8	1	21.2	5	71	.084
1.5KC16	12.9	14.4	17.6	1	23.5	5	64	.086
1.5KC16A	13.6	15.2	16.8	1	22.5	5	67	.086
1.5KC18	14.5	16.2	19.8	1	26.5	5	56.5	.088
1.5KC18A	15.3	17.1	18.9	1	25.2	5	59.5	.088
1.5KC20	16.2	18.0	22.0	1	29.1	5	51.5	.090
1.5KC20A	17.1	19.0	21.0	1	27.7	5	54	.090
1.5KC22	17.8	19.8	24.2	1	31.9	5	47	.092
1.5KC22A	18.8	20.9	23.1	1	30.6	5	49	.092
1.5KC24	19.4	21.6	26.4	1	34.7	5	43	.094
1.5KC24A	20.5	22.8	25.2	1	33.2	5	45	.094
1.5KC27	21.8	24.3	29.7	1	39.1	5	38.5	.096
1.5KC27A	23.1	25.7	28.4	1	37.5	5	40	.096
1.5KC30	24.3	27.0	33.0	1	43.5	5	34.5	.097
1.5KC30A	25.6	28.5	31.5	1	41.4	5	36	.097
1.5KC33	26.8	29.7	36.3	1	47.7	5	31.5	.098
1.5KC33A	28.2	31.4	34.7	1	45.7	5	33	.098
1.5KC36	29.1	32.4	39.6	1	52.0	5	29	.099
1.5KC36A	30.8	34.2	37.8	1	49.9	5	30	.099
1.5KC39	31.6	35.1	42.9	1	56.4	5	26.5	.100
1.5KC39A	33.3	37.1	41.0	1	53.9	5	28	.100
1.5KC43	34.8	38.7	47.3	1	61.9	5	24	.101
1.5KC43A	36.8	40.9	45.2	1	59.3	5	25.3	.101
1.5KC47	38.1	42.3	51.7	1	67.8	5	22.2	.101
1.5KC47A	40.2	44.7	49.4	1	64.8	5	23.2	.101
1.5KC51	41.3	45.9	56.1	1	73.5	5	20.4	.102
1.5KC51A	43.6	48.5	53.6	1	70.1	5	21.4	.102
1.5KC56	45.4	50.4	61.6	1	80.5	5	18.6	.103
1.5KC56A	47.8	53.2	58.8	1	77.0	5	19.5	.103
1.5KC62	50.2	55.8	68.2	1	89.0	5	16.9	.104
1.5KC62A	53.0	58.9	65.1	1	85.0	5	17.7	.104
1.5KC68	55.1	61.2	74.8	1	98.0	5	15.3	.104
1.5KC68A	58.1	64.6	71.4	1	92.0	5	16.3	.104
1.5KC75	60.7	67.5	82.5	1	108.0	5	13.9	.105
1.5KC75A	64.1	71.3	78.8	1	103.0	5	14.6	.105
1.5KC82	66.4	73.8	90.2	1	118.0	5	12.7	.105
1.5KC82A	70.1	77.9	86.1	1	113.0	5	13.3	.105
1.5KC91	73.7	81.9	100.0	1	131.0	5	11.4	.106
1.5KC91A	77.8	86.5	95.5	1	125.0	5	12.0	.106
1.5KC100	81.0	90.0	110.0	1	144.0	5	10.4	.106
1.5KC100A	85.5	95.0	105.0	1	137.0	5	11.0	.106
1.5KC110	89.2	99.0	121.0	1	158.0	5	9.5	.107
1.5KC110A	94.0	105.0	116.0	1	152.0	5	9.9	.107

Vf at 100 AMPS PEAK, 8.3 MSEC SINE WAVE equals 3.5 VOLTS MAXIMUM

TransZorbs™ can be used in series or parallel to increase their power handling capability. No precautions are required when using TransZorbs in a series string and power dissipation for two or more devices of the same type is equally shared. When using TransZorbs in parallel it is necessary for the units to be closely matched (approx. 1 volt of each other) in order for equal sharing to take place. Matched sets can be ordered from the factory for a small additional charge.

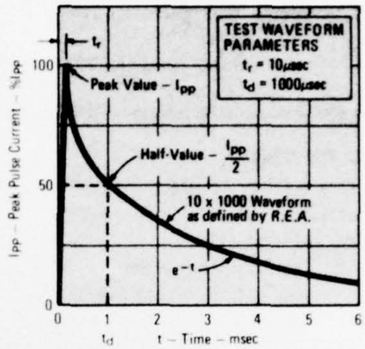

FIGURE 3 — Pulse Wave Form

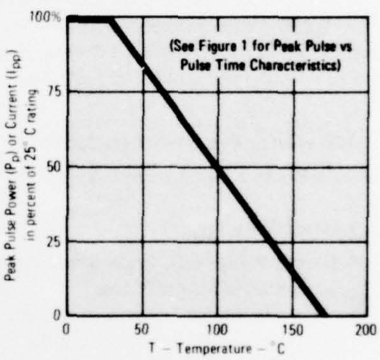

FIGURE 4 — Derating Curve

Non-standard voltage types between those tabulated may be specified as illustrated:

Family Type — Nominal BV — Tolerance Suffix

1.5KC 7.2 A

BV Will be Nominal BV ±5% for "A" suffix types and ±10% for non-suffix types at the test current of the next lower standard voltage type.

V_R Will be 85% of Nominal BV for "A" suffix type and 81% of Nominal BV for non-suffix types.

V_C Will be proportionally interpolated between the two neighboring standard types.

I_R Will be that of the next lower standard type.

I_{PP} Will be proportionately interpolated between the two neighboring standard types.

BIPOLAR APPLICATIONS

For Bipolar use C or CA Suffix for types 1.5KC7.5 through types 1.5KC110. Electrical characteristics apply in both directions.

GENERAL SEMICONDUCTOR INDUSTRIES INC 2001 West Tenth Place, Tempe, Arizona 85281 • 602/968-3101 • TWX910-950-1942
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ELECTRICAL CHARACTERISTICS:

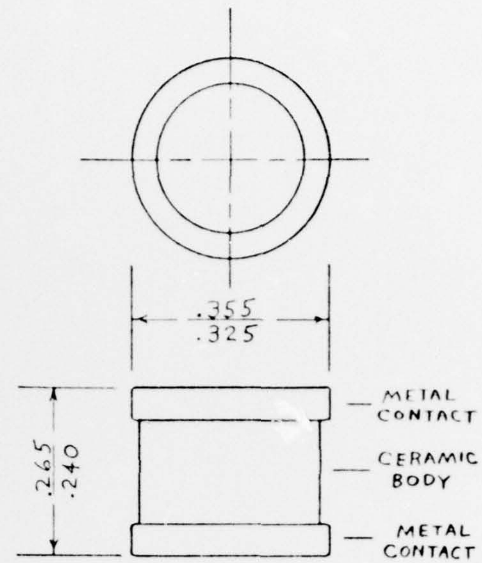
Breakdown Voltage: BV @ 10mA: 6.66V min., 8.14V max.

Reverse Leakage Current: Ir @ 5.0V: 1500μA max.

Clamping Voltage @ 70A I_{pp}: 12V max.

Maximum Peak Pulse Current I_{pp}:
70A down to ½ crest value in 1msec.

Capacitance @ 0V Bias: 250pf max.



GENERAL SEMICONDUCTOR INDUSTRIES, INC. 2001 WEST TENTH PLACE • TEMPE, ARIZONA 85281	DRAWN BY J PIZZICAROLI	
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CUSTOMER: FLORIDA INSTITUTE OF TECHNOLOGY / FAA		
CUSTOMER PART NO:		
GSI PART NO: GZ60316B		

Low Capacitance Tranzorb

Appendix D. References/Bibliography

1. R.M. Cosel, A.W. Revay, Jr., J. Stahman: "FAA Lightning Protection Study: Lightning Simulation Tests of Communication Cables," Final Report, January 1974, Report No. FAA-RD-74-71

2. E.E. Sunde: "Lightning Protection of Buried Toll Cable," B.S.T.J., 24, pp. 253-300, 1955.

3. D.W. Bodle and P.A. Gresh: "Lightning Surges in Paired Telephone Cable Facilities," B.S.T.J., 40 pp. 547-576, 1960.

4. D.A. Douglass: "Lightning Induced Current Surges on a Buried Multicoaxial Cable System," Wire Journal, January 1973.

5. E. Bennison, A.J. Ghazi and P. Ferland: "Lightning Surges in Open Wire, Coaxial and Paired Cables," IEEE Trans., COM-21, No. 10, pp. 1136-1143, 1973.

6. G.K. Huddleston, J.D. Nordgard and R.W. Larson: "FAA Lightning Protection Study - Lightning Protection Requirements for AN/GRN-27 (V) Instrument Landing System," Final Report. FAA Report RD-74-131, April 1974.

7. C. Chen: "FAA Lightning Protection Study: Lightning Protection Devices," Final Report, April 1974. Report No. FAA-RD-74-104.

8. A.V. Bazarian: "Gas Discharge Devices for use in Transient Voltage Protection and Electrical Energy Transfer," Technical Manual TPTM-2-73. Signalite, Neptune, New Jersey, (1973).

9. F.B. Golden, and R.W. Fox: "GE-MOV Varistors Voltage Transient Suppressors," General Electric Company Application Note 200.60 (July, 1972).

10. M.J. Coyle: "Designers' Guide to Circuit Protectors," MCG Electronics Inc., Deer Park, New York.

11. D.C. Wunsch, R.L. Cline and G.R. Case: "Semiconductor Vulnerability," Technical Report No. AFWL-TR-73-119, Braddock, Dunn and McDonald, Inc., 1973.

12. R.L. Davies and F.E. Gentry: "Control of Electric Field at the Surface of P-N Junctions," IEEE Transactions on Electron Devices, ED-11, pp. 313-322, July 1964.

13. Transistor D.A.T.A. Book, 35th Edition, Autumn 1973, p. 200 - line 55.

14. Semiconductor Diode D.A.T.A. Book, D.A.T.A. Inc., Orange, New Jersey, 33rd Edition, Spring 1974.

15. Hewlett Packard Components, Diode and Transistor Designs Catalog, May 1974.

16. Wilcox Corporation, private communication.

17. Private communication with G.K. Huddleston.